I'm not a robot

The fundamental reason summer is hotter than winter lies in the Earth’s tilt on its axis, not its distance from the Sun. While it might seem logical that the Earth is closer to the Sun during summer, that’s actually not the case. The Earth’s orbit around the sun is elliptical, meaning it’s not a perfect circle. In reality, Earth is at its closest point to the Sun in January (perihelion) and furthest in July (aphelion). However, this distance change is minimal and doesn’t significantly impact seasonal temperatures. The real driving force behind the seasons is the 23.5-degree tilt of the Earth’s rotational axis relative to its orbital plane around the Sun. The Impact of Earth’s Tilt This tilt means that during half of the year, the Northern Hemisphere leans towards the Sun and receives more direct sunlight. Simultaneously, the Southern Hemisphere leans away from the Sun and receives less direct light. This situation reverses every six months as the Earth orbits. Direct Sunlight and Angle of Incidence When a hemisphere is tilted toward the Sun, it experiences more direct sunlight. Think of it like shining a flashlight straight onto a wall versus shining it at an angle. The light directly hitting the wall is concentrated, making it brighter and warmer. When sunlight hits the Earth directly, it delivers more solar energy to a specific area, causing the temperature to rise. During summer, the sun’s rays strike the Earth at a steeper angle, concentrating the energy. Conversely, during winter, the sun’s rays hit at an oblique angle, spreading the same amount of energy over a larger area and reducing the intensity of heat. This is also why the sun appears lower in the sky during the winter months. Daylight Hours Furthermore, the hemisphere tilted toward the Sun experiences longer daylight hours. This extra time under the sun provides more opportunity for the land, air, and water to absorb heat. The combination of more direct rays of sunlight and more hours of daylight leads to a greater overall input of solar radiation, and consequently, higher temperatures during summer. In winter, the opposite occurs: shorter daylight hours and less direct sunlight result in lower temperatures. Other Factors Influencing Temperature While the Earth’s tilt is the primary driver of the seasons, other factors can influence the temperature of a specific region during summer or winter. These include: Ocean currents: Warm ocean currents, like the Gulf Stream, can transport warm water and air towards certain land masses, moderating temperatures. This is why regions like the UK experience milder winters compared to areas at similar latitudes. Land vs. Water: Land tends to heat up and cool down faster than water. In coastal areas, the presence of a large body of water can have a cooling effect during the summer and a warming effect during winter. The thermal capacity of water is significantly higher than that of land, meaning it takes more energy to change its temperature. Weather patterns: Specific weather phenomena like El Niño, can cause significant variations in global temperatures. For example, the exceptionally high sea surface temperatures fueled by El Niño in 2023 contributed to record-breaking summer heat. Altitude: Higher altitude locations generally experience colder temperatures than lower altitude locations, regardless of the season. Local Climate: Local factors and weather patterns also play an important role. Some regions have unique micro-climates that can create differences from the general seasonal norms. In summary, the intensity of summer heat is primarily due to the Earth’s axial tilt, which results in more direct sunlight and longer daylight hours. These factors combine to deliver more solar energy to a specific hemisphere during its summer months, resulting in warmer temperatures. Frequently Asked Questions (FAQs) 1. Is it true that the Earth is closer to the Sun during summer? No, this is a common misconception. The Earth is actually closest to the Sun in January (perihelion) and furthest away in July (aphelion). However, this slight variation in distance doesn’t significantly affect seasonal temperatures. 2. What is the primary reason why we have seasons? The seasons are primarily caused by the Earth’s axial tilt. The 23.5-degree tilt causes different hemispheres to lean towards or away from the Sun as the Earth orbits, resulting in variations in sunlight intensity and daylight hours. 3. Why is it colder in the winter than in the summer? During winter, the hemisphere is tilted away from the Sun, resulting in less direct sunlight, a more oblique angle of incidence and shorter daylight hours. All these contribute to lower temperatures. 4. Does a hotter summer mean a colder winter? There is no direct correlation between hot summers and cold winters. Meteorological factors in summer and winter operate largely independently. 5. What role does daylight hours play in temperature? Longer daylight hours in summer allow the Earth’s surface to absorb more solar radiation, which translates to higher temperatures. Conversely, shorter daylight hours in winter result in less heat absorption and colder temperatures. 6. How does the angle of the sun’s rays affect temperature? Direct sunlight, which occurs when a hemisphere is tilted towards the sun, provides more concentrated energy, causing the area to heat up more effectively. Oblique sunlight, which occurs in winter, spreads the same energy over a larger area, reducing the heat intensity. 7. What is the impact of El Niño on summer temperatures? El Niño can cause exceptionally high sea surface temperatures, which then contribute to record-breaking summer heat by impacting global weather patterns. The warmer ocean increases temperatures across the globe. 8. Do ocean currents influence seasonal temperatures? Yes, warm ocean currents such as the Gulf Stream can transport heat, helping to moderate the climate of certain regions and leading to warmer winters than expected. 9. How does land and water affect temperature differences? Land heats up and cools down faster than water. The higher thermal capacity of water means that it tends to moderate temperatures in coastal regions, making summers cooler and winters warmer. 10. Are winters getting colder over time? Overall, winters are warming, not cooling, due to climate change. Analysis shows that winters around the Pacific Northwest have warmed by 1 degree Fahrenheit and parts of the Midwest and East Coast have warmed by up to 5 degrees since 1970. 11. Are summers getting longer? Yes, summers are indeed getting longer due to the effects of climate change. One study found summer’s length increased from 78 to 95 days on average between 1952 and 2011, and they could potentially reach six months by the end of the century. 12. Is it possible to predict how hot the summer will be? While precise seasonal predictions can be challenging, scientists and weather agencies can make general forecasts based on climate models, past trends, and phenomena like El Niño. 13. Why is the UK not as cold as Canada in the winter? The UK benefits from the warm Gulf Stream, which brings warm water and air from the Gulf of Mexico. This helps to moderate the UK’s climate, making it milder than other regions at similar latitudes, like Canada, which do not have the same ocean current influence. 14. Does a wet winter mean a hot summer? There is no direct link between a wet winter and a hot summer. A wet winter typically refers to above-average precipitation, but these weather patterns don’t directly influence summer temperatures. 15. What happens to our bodies during summer heat? When your body gets too warm, it may overheat leading to sweating, muscle cramps, weakness, a heightened heart rate, and nausea. « Back to Meteorology, Climatology page Because the earth’s axis is tilted.Earth at the beginning of each season. From National Weather Service, National Oceanic and Atmospheric Administration Web site.It is all about the tilt of the Earth’s axis. Many people believe that the temperature changes because the Earth is closer to the sun in summer and farther from the sun in winter. In fact, the Earth is farthest from the sun in July and is closest to the sun in January!During the summer, the sun’s rays hit the Earth at a steep angle. The light does not spread out as much, thus increasing the amount of energy hitting any given spot. Also, the long daylight hours allow the Earth plenty of time to reach warm temperatures.During the winter, the sun’s rays hit the Earth at a shallow angle. These rays are more spread out, which minimizes the amount of energy that hits any given spot. Also, the long nights and short days prevent the Earth from warming up. Thus, we have winter!Clockwise from top left: Winter in Yellowstone National Park. National Park Service Web site. Rural Alabama in the spring. Carol M. Highsmith Collection, Library of Congress. Soybean and corn fields ready for harvesting in late summer in Carroll County, Indiana. Carol M. Highsmith Collection, Library of Congress. Colorado’s Delores River Valley in autumn. Carol M. Highsmith Collection, Library of Congress.Published: 11/19/2019. Updated 6/14/2024. Author: Science Reference Section, Library of Congress Asimov, Isaac. Isaac Asimov’s guide to earth and space. New York, Random House. 1991. 285 p. Bremer, Scott, editor. Changing seasonality: how communities are revising their seasons. Berlin, De Gruyter. 2024. 251 p. Fischer, Luke, David Macauley, editors. The seasons : philosophical, literary, and environmental perspectives. Albany, State University of New York. 2021. 277 p. Jacobson, Bray. Cycles in space. New York, Gareth Stevens Publishing. 2020. 32 p. (Juvenile) Miller, Derek L. Earth, Sun, and Moon : cyclic patterns of lunar phases, eclipses, and the seasons. New York, Cavendish Square Publishing. 2017. 112 p. Thompson, Luke. Earth. New York, PowerKids Press, 2001. 24 p. (Juvenile) Woodgate, Vicky. The magic of seasons. New York, DK Publishing. 2022. 72 p. (Juvenile) Seasons. Summer. Summer solstice. Weather. Winter. Winter solstice. Have a question? Ask a science librarian Many people believe that Earth is closer to the Sun in the summer and that is why it is hotter. And, likewise, they think Earth is farthest from the Sun in the winter. Although this idea makes sense, it is incorrect. It is true that Earth's orbit is not a perfect circle. It is a bit lop-sided. During part of the year, Earth is closer to the Sun than at other times. However, in the Northern Hemisphere, we are having winter when Earth is closest to the Sun and summer when it is farthest away! Compared with how far away the Sun is, this change in Earth's distance throughout the year does not make much difference to our weather. There is a different reason for Earth's seasons. Earth's axis is an imaginary pole going right through the center of Earth from "top" to "bottom." Earth spins around this pole, making one complete turn each day. That is why we have day and night, and why every part of Earth's surface gets some of each. Earth has seasons because its axis doesn't stand up straight. But what caused Earth to tilt? Long, long ago, when Earth was young, it is thought that something big hit Earth and knocked it off-kilter. So instead of rotating with its axis straight up and down, it leans over a bit. By the way, that big thing that hit Earth is called Theia. It also blasted a big hole in the surface. That big hit sent a huge amount of dust and rubble into orbit. Most scientists think that that rubble, in time, became our Moon. As Earth orbits the Sun, its tilted axis always points in the same direction. So, throughout the year, different parts of Earth get the Sun’s direct rays. Sometimes it is the North Pole tilting toward the Sun (around June) and sometimes it is the South Pole tilting toward the Sun (around December). It is summer in June in the Northern Hemisphere because the Sun's rays hit that part of Earth more directly than at any other time of the year. It is winter in December in the Northern Hemisphere, because that is when it is the South Pole's turn to be tilted toward the Sun. Earth's lopsided orbit Earth's perihelion (point closest to Sun) = 91,400,000 miles from Sun Earth's aphelion (point farthest from Sun) = 94,500,000 miles from Sun While that is a difference of over 3 million miles, relative to the entire distance, it isn’t much. And, believe it or not, aphelion (when Earth is farthest from the Sun) occurs in July, and perihelion (when we are closest) occurs in January. For those of us who live in the Northern Hemisphere where it's summer in July and winter in January, that seems backwards, doesn't it? That just goes to prove that Earth's distance from the Sun is not the cause of the seasons. Related Resources for Educators Seasons (Educator Guide to go with Seasons Spotlite video) Seasons (Nearpod Lesson to go with Seasons Spotlite video) Our World: Sun's Position Sun's Position (Educator Guide to go with Sun's Position Spotlite video) Sun's Position (Nearpod Lesson to go with Sun's Position Spotlite video) If you are out in sunlight in the summer, there's not much doubt that the direct sunlight from the Sun feels warmer than it did in winter. The Sun itself hasn't changed so why is this? This effect is caused by the Earth's atmosphere. When the Sun is lower in the sky, the sunlight has to travel through a thicker layer of the Earth's atmosphere than when it is higher in the sky. This extra thickness of atmosphere absorbs some of the radiation from the Sun and makes it feel less strong. This effect is especially important for ultraviolet light, which is why it is safer to be out in the Sun in the early morning and late afternoon rather than around midday Today, March 20th, is one of only two days this year when the sun will directly over the equator. (The other will be September 22nd) Today, the length of the day and the length of the night are equal – in every place on earth. How cool is that! From tomorrow, the days will be longer than the nights in the Northern Hemisphere and they will officially enter spring. This is the ‘Vernal Equinox’. (‘ver’ is Latin for spring). Here in the South, it has officially been autumn since March 1st, not withstanding that the true ‘Autumnal Equinox’ is today. (‘autumn’ is already in latin!) The Bureau of meteorology says it sticks to calendar months because “it works nicely for everybody”. Contrary to what most people believe, the reason that summer is hotter than winter is not because we are closer to the sun in summer. In fact, in the Northern Hemisphere, the orbit of the earth takes us further from the sun in summer. Summer is hotter than winter due to the tilt in the axis of the earth of 23 degrees. If there was no tilt, every day would be an equinox and there would be no seasons. Every day would be a bit like today. These photos from NASA show the amount of sunlight hitting the earth on different days. You can see the spring and summer equinoxes in the R hand photos. The top L is summer in the Southern Hemisphere, and the bottom L is summer in the Northern Hemisphere. NASA also has a time lapse video of the process Because of this tilt, in summer – the days are longer, with more hours of sunlight heating the earth. – the sun is higher in the sky, meaning more sunlight shines on the earth more directly. I think the second explanation squibs it a bit, and would benefit from a more detailed discussion. (The most viewed post on this blog is ‘Why is Summer Hotter than Winter’, posted on the (southern hemisphere) vernal equinox in 2011. The rest of this article is an updated version of that article.) Each morning the sun rises in the east and sets in the west. About midday it is at it highest point in the sky (the zenith) A shadow stick would cast no shadow if the sun was directly overhead – but this only happens if you are located in the tropics (and even then on only two days a year). The tropics lie within 23.5 degrees of each side of the equator, between the Tropic of Cancer and the Tropic of Capricorn. Rockhampton, Longreach and Alice Springs are close to the Tropic of Capricorn. The Tropic of Cancer passes through India, Saudi and Mexico – so no place in Europe and no place in the USA is tropical. The Arctic and Antarctic Circles (at 66 degrees) mark the points north (or south) where there will be some days (or nights) that are 24 hours long. How ‘overhead’ the sun is makes a difference to how ‘strong’ it is – i.e., how much it heats things up. The less overhead it is, the less effective at heating things up. We notice the difference in heat between the high-in-the-sky sun at noon and the low-in-the-sky sun at sunset. These ‘overhead’ factors must be more important than the length of day. The days are much much longer in Stockholm (~ Lat 60 degrees N) in summer than they are here in Alstonweb (~ Lat 30 degrees S) but it is still much warmer here. There are two reasons why being higher in the sky, or more overhead, makes a difference The Area Effect (The concentration of light – how spread out it is at any point.) The more the sun is directly overhead , the less spread out are its rays when they hit the earth. A torch shone straight down towards the floor gives a a circle of light, but tilt it a bit sideways and the light forms a stretched oval shape. The same amount of energy covers a larger area, so at any one point the light rays are less intense. The Air Mass Effect The more the sun is directly overhead, the less distance it has to pass through the earth’s atmosphere. The earth is protected by the gases that make up the atmosphere. The gas molecules prevent the sun’s heat from burning us up by reflecting some rays and absorbing others. If the sun is less directly overhead, the rays have to pass through more of the atmosphere, and therefore are obstructed by more of the gas molecules. The earth’s atmosphere is 480 km thick, which means at the Equator the sun’s rays pass through 480 km of air. Here in Alstonweb (30°S), because the sun’s rays are angled to the atmosphere, the rays pass through 548 km of atmosphere (480/cos 30°) At Stockholm (60°N), they have to pass though 960 km (480/cos 60°) So the sun rays at Stockhom have passed through twice as much atmosphere as the sun’s rays at the equator. They are exhausted by the time they reach Sweden! Happy Vernal Equinox to our friends in the North, and happy Autumnal Equinox to us.