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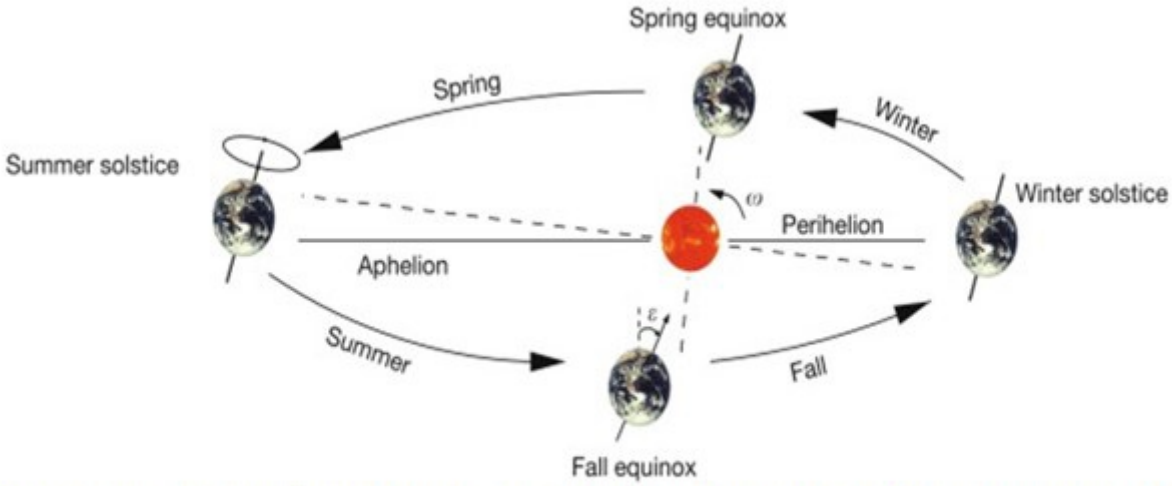
V - The Sun, Seasons and Weather Influences on Sunlight

A passive solar greenhouse depends entirely on the sun, so understanding how the sun moves across the sky and how the weather affects sunlight is essential. In this chapter, we'll step back to look at the solar system and then bring the focus down to your greenhouse site. We will then discuss how the weather impacts a passive solar greenhouse.

The earth, the sun, and the seasons

A common misconception is that seasons are caused by the Earth being closer to the sun in summer and farther away in winter. Many science book diagrams add to this confusion by showing an exaggeratedly elliptical orbit, with the Earth at one end of the ellipse near the sun and at the other end far away. It seems to make sense: closer means hotter, farther means colder. But this doesn't explain why it is summer in the Southern Hemisphere when it is winter in the Northern Hemisphere.

In reality, the Earth's orbit is almost circular, but the Sun is not in the center of Earth's orbit. The distance between Earth and Sun is smaller in the Northern hemisphere winter (at perihelion) than in the summer by about 3.1 million miles. The real reason for the seasons is the tilt of the Earth's axis, which is 23.5° relative to its orbital plane. This tilt always points toward the North star, no matter where the Earth is in its orbit. Thus, when the axis tilts away from the sun, we experience winter with shorter days and less direct sunlight. Conversely, when the axis tilts toward the sun, we experience summer with longer days and more concentrated sunlight.



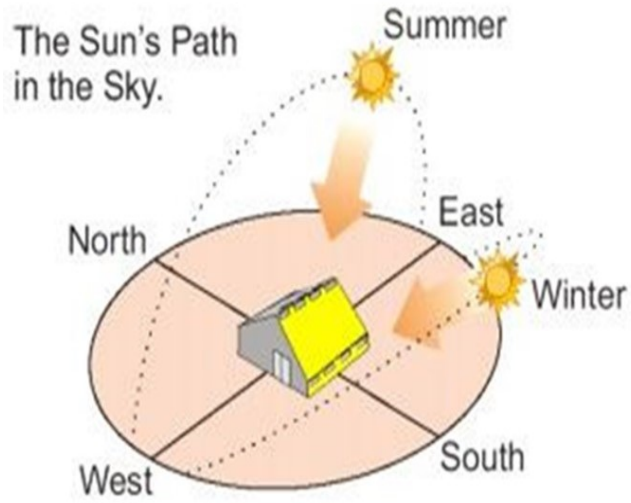
Source: Lucas J Lourens & Erik Tuenter. The Role of Variations of the Earth's Orbital Characteristics in Climate Change. In: Trevor M. Letcher, ed., Climate Change – Observed Impacts on Planet Earth. Elsevier, 2009, pp 103-123. https://doi.org/10.1016/B978-0-444-53301-2.00005-1

This tilt not only creates the seasons but also makes passive solar design possible. The difference between the low winter and high summer sun can be used to admit sunlight and heat when needed and reflect it when not. A good analogy is a flashlight aimed straight at a wall which makes a small, bright circle; when the flashlight is tilted to skim across the wall, it makes a long dim oval over a larger area even though the amount of light energy emitted by the flashlight is the same.

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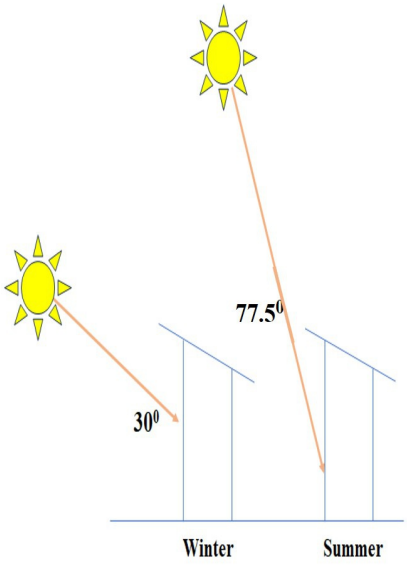
Daily Sun Paths

Think about where you notice the sun in the sky in summer versus winter. In summer, the sun rises higher and stays overhead longer, giving long, hot days. In winter, it hugs the horizon, creating short days and less intense sunlight. This daily and seasonal pattern directly influences how much energy your greenhouse captures. The genius of SunCatcher's PSG design is using the difference in the sun's two paths to an advantage. During the winter, the PSG is able to harness as much light as possible for both plant growth and heating the structure. While in summer it is able to reflect enough light to keep the PSG from overheating while still providing enough light for plant growth. Most [food] crops are so-called C-3 plants, which shut down when grown in full sun and temperatures exceed 25^{0}C (77^{0}F) between 11 am and 5pm. You can see plants drooping their leaves during this time.



In winter, when the sun is low in the southern sky, the SunCatcher's south-facing glazing (tilted at about 60°) catches the rays close to perpendicular, maximizing light entry. In summer, when the sun is high, much of the light reflects off the glazing, reducing overheating while still allowing enough diffuse light for photosynthesis. This seasonal "switch" is the genius of passive solar design.

Photos of solar test units show the dramatic difference: in winter, sunlight streams deep inside; in summer, much of it reflects away. The glazing angle works like a filter, automatically balancing light and heat.



Sun angles at solar noon on solstices



Solar noon – winter solstice



Solar noon – summer solstice

Weather and clouds

Weather adds another layer of complexity. Air temperature changes follow solar patterns: it is coldest about 30 minutes after sunrise when surfaces have been radiating heat to the night sky, then it warms steadily until one to three hours after solar noon, before cooling again in the evening. Cloud cover, storms, and air masses effect how much solar radiation reaches the surface.

Warm air can hold more moisture than cold air, so as moist air cools, it eventually reaches saturation, forming clouds, fog, dew or precipitation. The amount of moisture in the air is usually expressed as its relative humidity – that is, the actual amount of moisture in the air as a percent of the total amount it can hold at a given temperature. As warm, humid daytime air cools overnight, it forms dew or frost on surfaces overnight, like moisture forms on a glass of ice water. The dew point, the temperature at which air becomes saturated, marks the boundary where condensation and phase changes occur.

Clouds are especially important. At night, clouds trap and re-radiate heat, making cloudy nights warmer than clear ones which is especially noticeable in winter. During the day, clouds reduce the amount of direct sunlight entering the greenhouse. For PSGs, this means cloudy weather reduces solar gain, while clear skies maximize it. Interestingly, the coldest winter days are often clear, because very cold air holds little moisture and therefore forms fewer clouds. This creates some of the sunniest conditions just when the greenhouse needs light and heat most.

Geographic and microclimate influences

Beyond daily weather, your site's geography matters. Several factors influence how warm or cold your greenhouse environment will be:

Altitude: Higher elevations are colder. On average, the temperature drops about 5.4°F per 1,000 feet (1^0C per 100 meter) gained in elevation when it's dry, and about 3.3°F if it is snowing or raining. This corresponds to a one degree increase in latitude.

Slope orientation: South and Southwest-facing slopes are warmer, north-facing slopes are colder. East slopes warm in the morning, west slopes in the afternoon.

Cold air drainage: Cold air is heavier than warm air and sinks into valleys at night, making low spots colder while pushing up warm valley air to somewhere mid-slope.

Bodies of water: Water bodies moderate temperatures by absorbing heat during the day and in summer, and releasing it at night and in the winter. Even a small pond can create microclimate effects, while oceans and large lakes influence entire regions.

Urban heat islands: Cities are warmer than the surrounding countryside due to the large amount of pavement, buildings, and waste heat from air conditioners, cars and industry. As a result, daytime temperatures in urban areas are 1-7^0 F higher than temperatures in outlying areas, with night time temperatures 2-5^0 F higher. The amount of urban tree cover also affects the temperature in cities - neighborhoods with greater tree cover remain a few degrees cooler than neighborhoods with little to no trees. The US EPA reference in Further Reading has a good diagram depicting air and surface temperatures across a rural-urban gradient.

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Why this matters for PSG design

All of these factors - seasonal tilt, daily sun paths, cloud cover, humidity, altitude, slope, bodies of water, and urban areas - affect how much solar energy your greenhouse can capture and retain. Understanding them helps you make informed decisions about site selection, glazing angle, and construction details.

The SunCatcher design takes advantage of these natural patterns. In winter, the low sun penetrates deeply to provide heat and light. In summer, high sun reflects off the glazing, preventing overheating. Cloud cover and humidity influence day-to-day performance, but the passive solar greenhouse is resilient because it works with natural cycles, not against them.

Further reading

Mazria, The Passive Solar Energy Book, pp. 5-12.

Carter, pp. 83-84 (Humidity)

Yanda & Fisher, The Food and Heat Producing Solar Greenhouse (John Muir Publications), pp. 517-518)

U.S. Environmental Protection Agency. 2025. What Are Heat Islands?