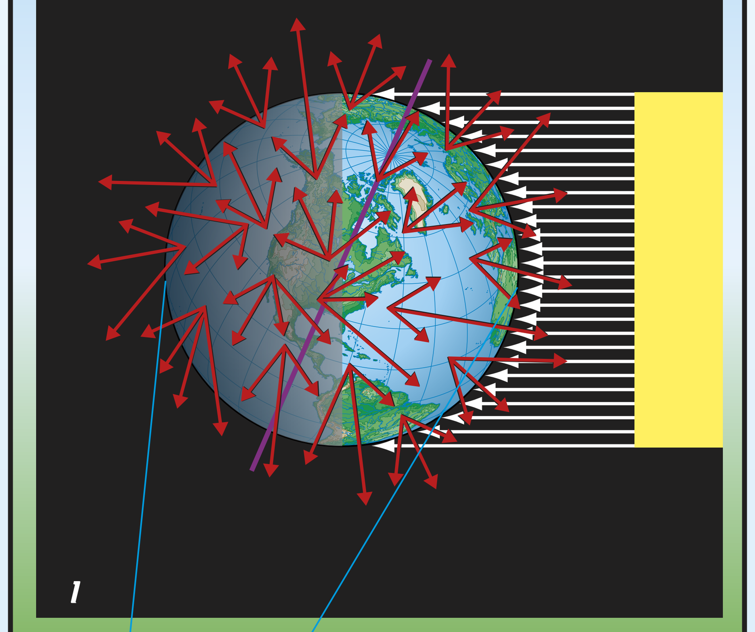
THE SEASONS

A TALE OF THE SUN, EARTH, AND TWO CITIES

At any time, half of Earth's surface is heated by sunlight, while the entire surface is cooled by Earth's emission of infrared light.



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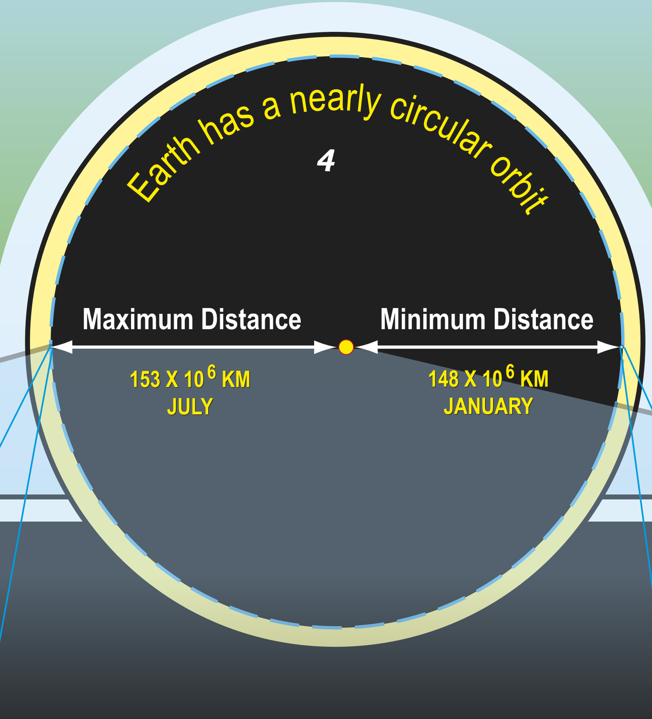
Some Details and Clarifications

The tropics receive roughly constant solar heating throughout the year. As a result, they essentially have no seasons.

At the tropics, the annual solar radiation absorbed by Earth exceeds the annual emitted infrared radiation. At the mid-latitudes, the annual solar radiation absorbed by Earth is approximately equal to the annual emitted infrared radiation. At the poles, the annual infrared radiation emitted by Earth exceeds the annual absorbed solar radiation.

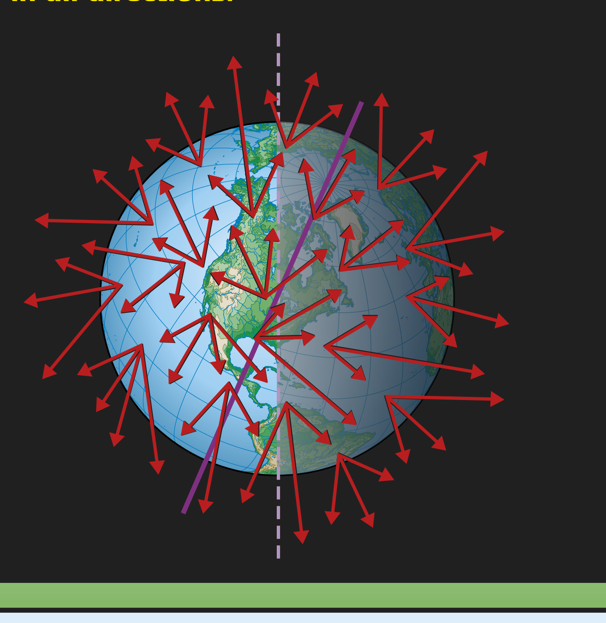
In most scientific literature, the angle of the Sun is measured with respect to the zenith, not the horizon as is done in this poster. The angle of the Sun measured from the zenith is called the zenith angle.

The seasons are almost entirely a consequence of the yearly changes in daylight hours and the angle between the Sun's rays and Earth's surface. Small variations in the Earth-Sun distance over a year are mostly irrelevant. The top half of the poster illustrates the causes of the seasons. The bottom half compares daylight hours, maximum daily Sun altitude, daily solar energy, and temperature data from a northern hemisphere city (New York City - 40° north latitude) and a southern hemisphere city (Wellington, New Zealand - 40° south latitude). The data analysis shown confirms these causes of the seasonal variations in solar energy.



ALL OBJECTS EMIT ELECTROMAGNETIC RADIATION. HIGHER TEMPERATURE OBJECTS EMIT AT SHORTER WAVELENGTHS.

Earth emits mostly infrared radiation in all directions.



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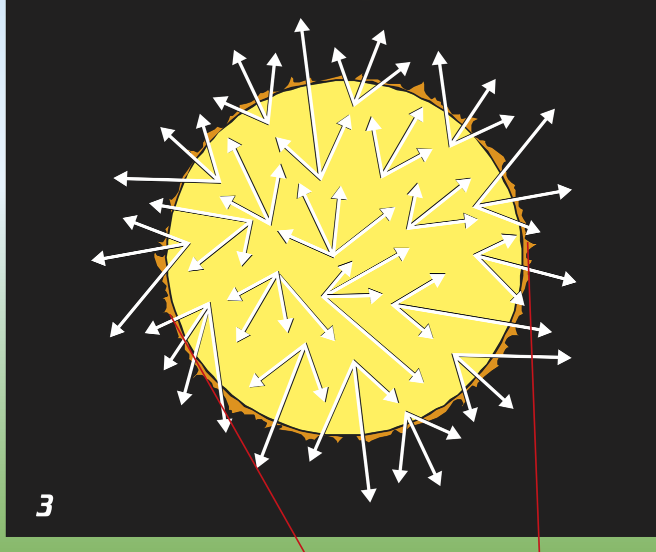
The Sun emits radiation in all directions. Slightly less than half of this radiation is emitted as visible light.



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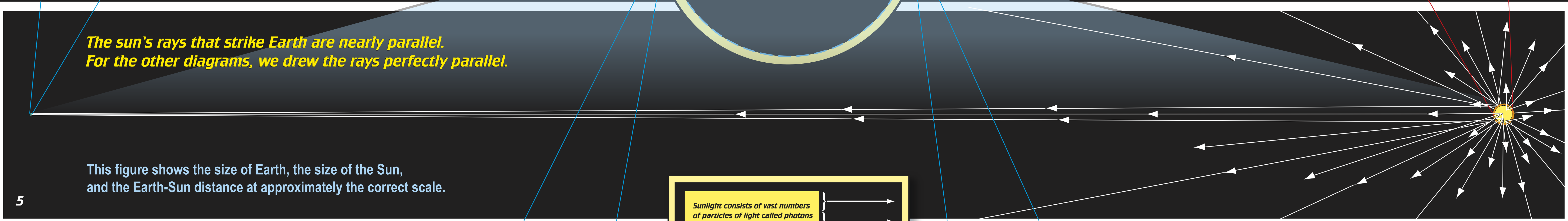
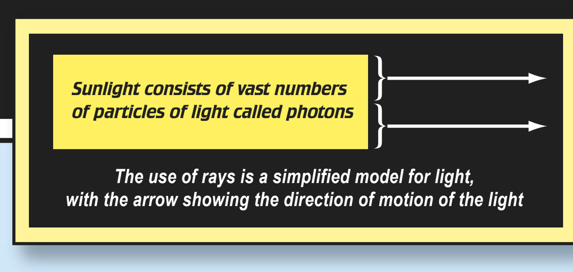


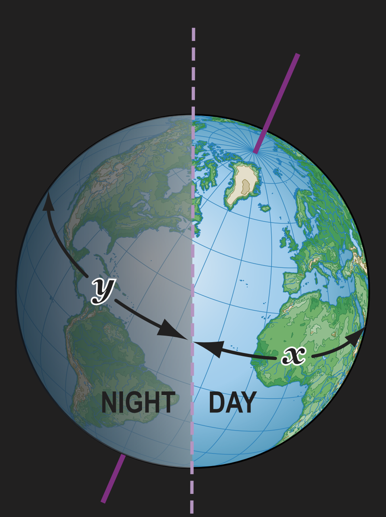
The sun's rays that strike Earth are nearly parallel. For the other diagrams, we drew the rays perfectly parallel.

This figure shows the size of Earth, the size of the Sun, and the Earth-Sun distance at approximately the correct scale.

5



The length of the line of latitude in daylight (x) divided by the total length shown (x+y) indicates the percentage of daylight hours at that latitude.



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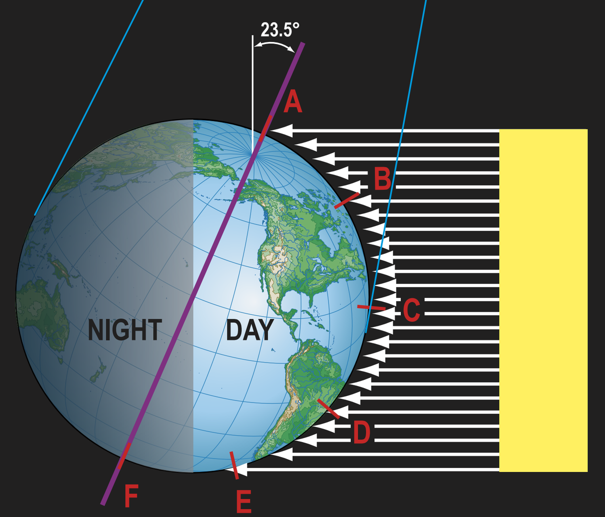


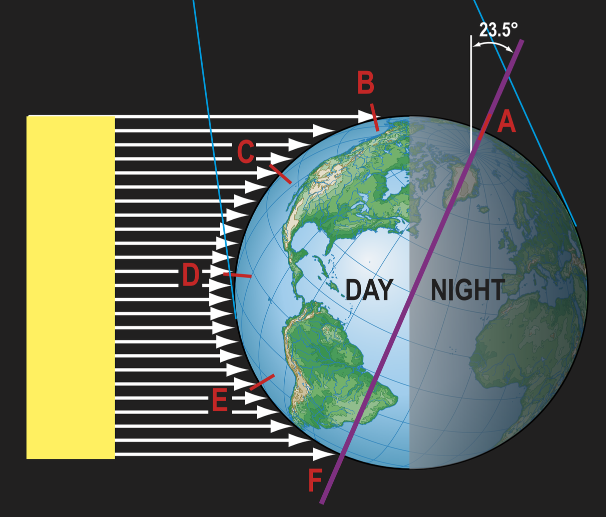
JULY

Summer in North America
Winter in South America

Count the number of the Sun's rays between

A – B
B – C
C – D
D – E
E – F

The greater the density of rays, the greater the solar heating, resulting in higher temperatures.



JANUARY

Winter in North America
Summer in South America

7

When the Sun is at an angle θ above the horizon, the concentration of sunlight on Earth's surface is reduced by a factor of sinθ compared to the concentration when the sun is directly overhead.

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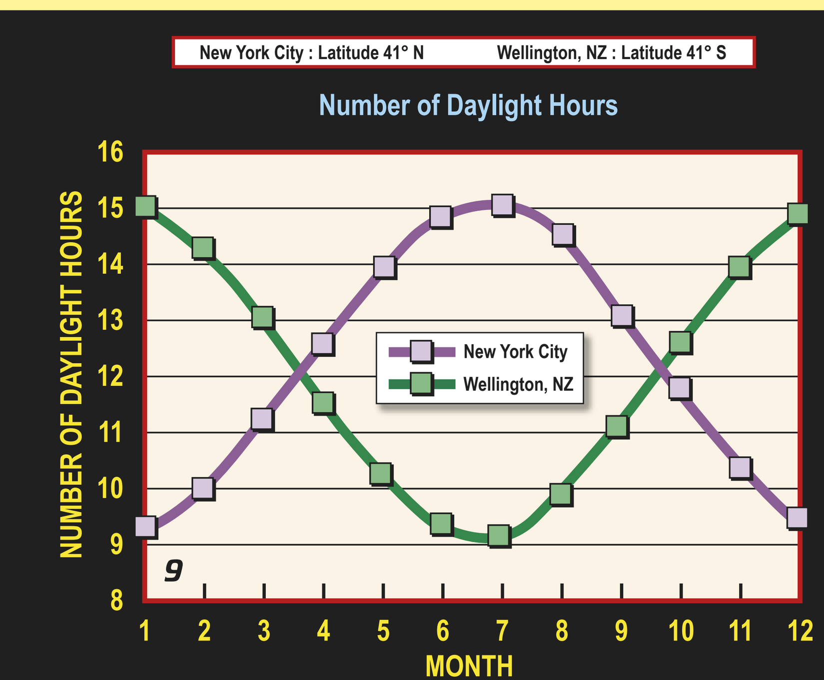
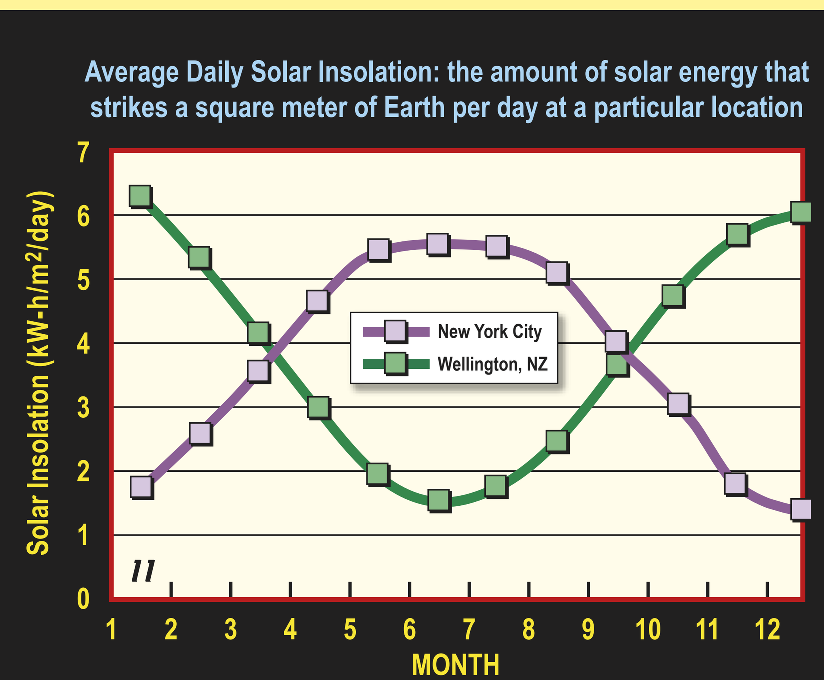
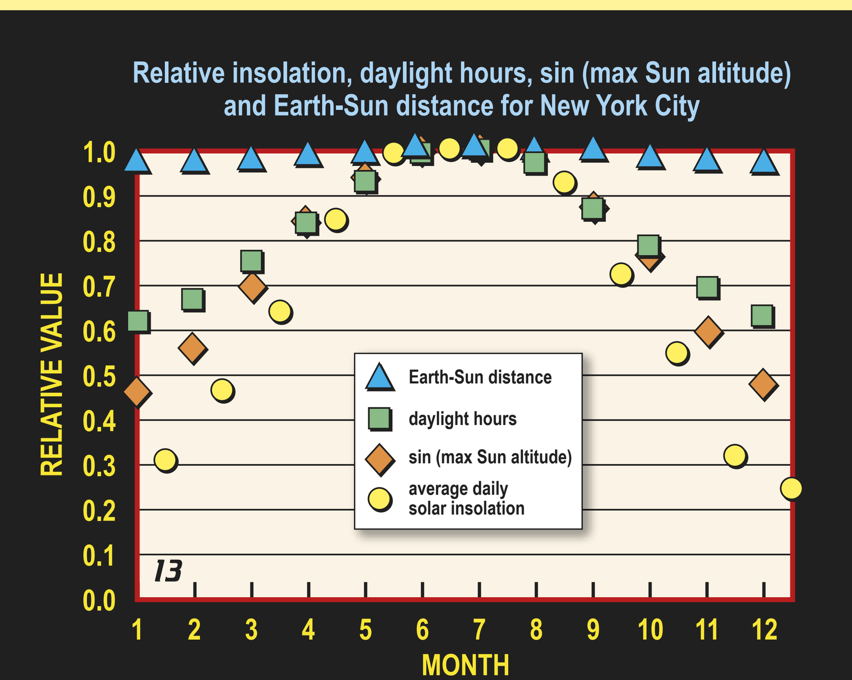
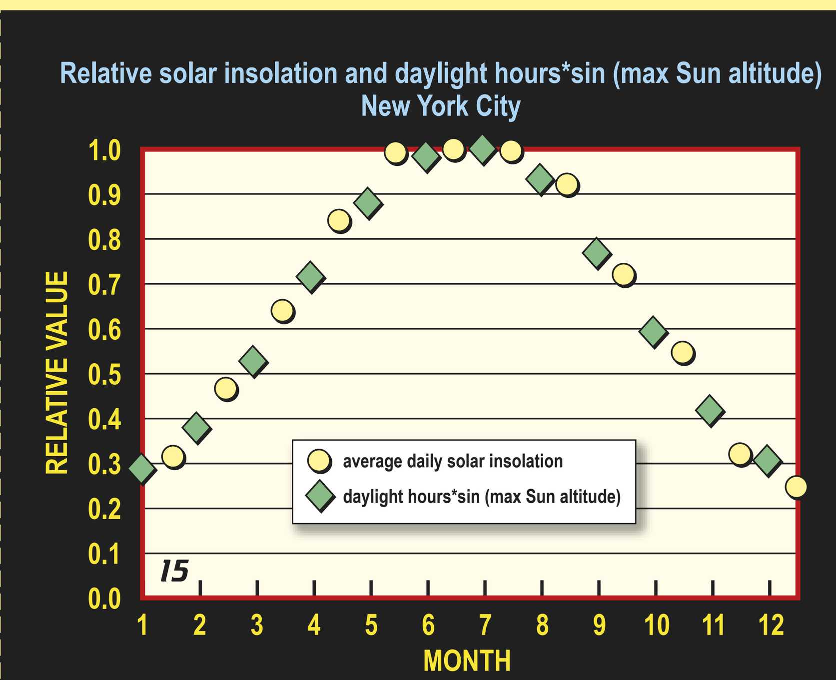
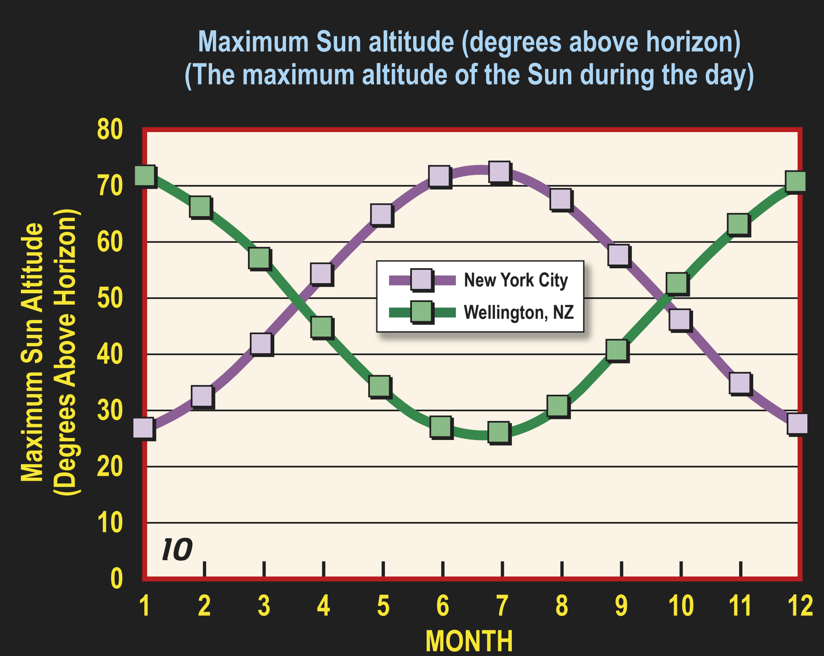
New York City : Latitude 41° N   Wellington, NZ : Latitude 41° S

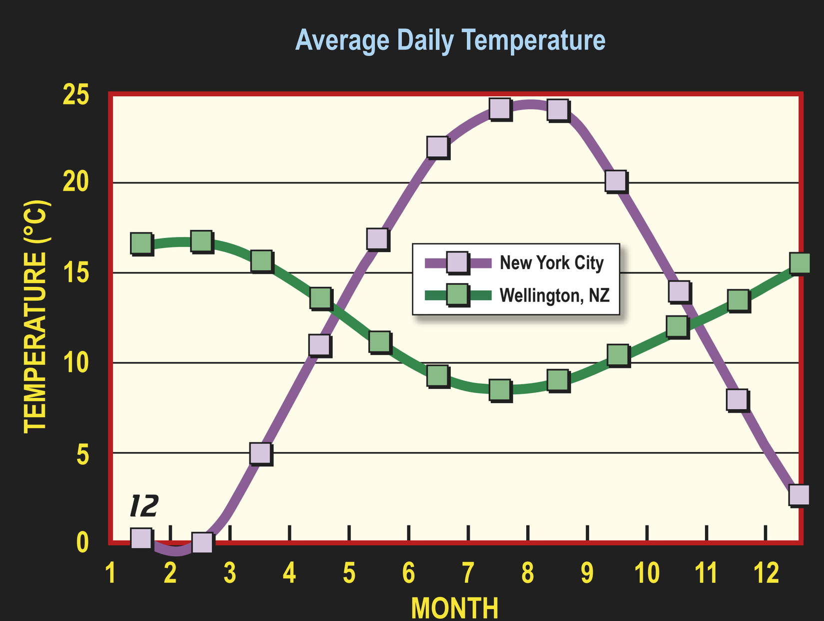


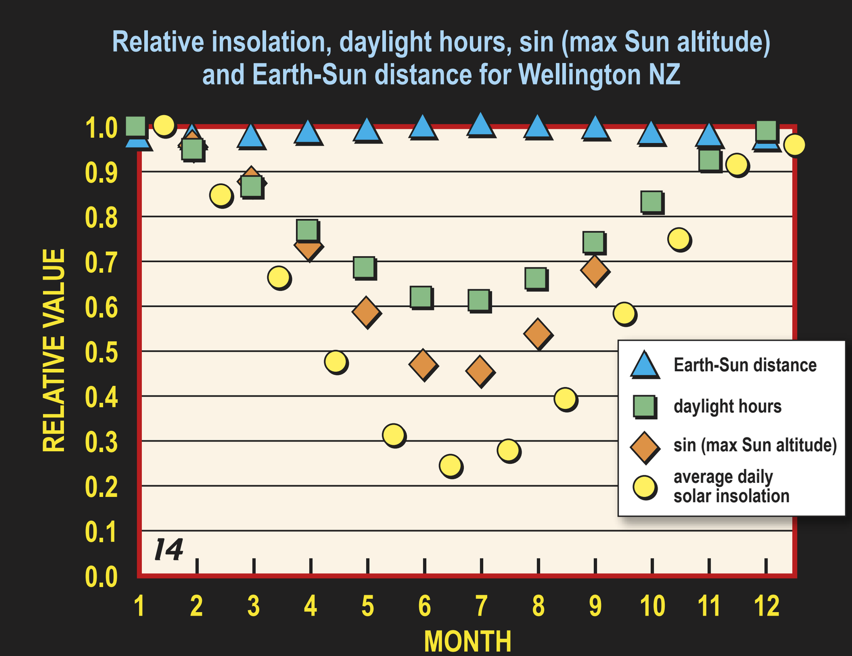


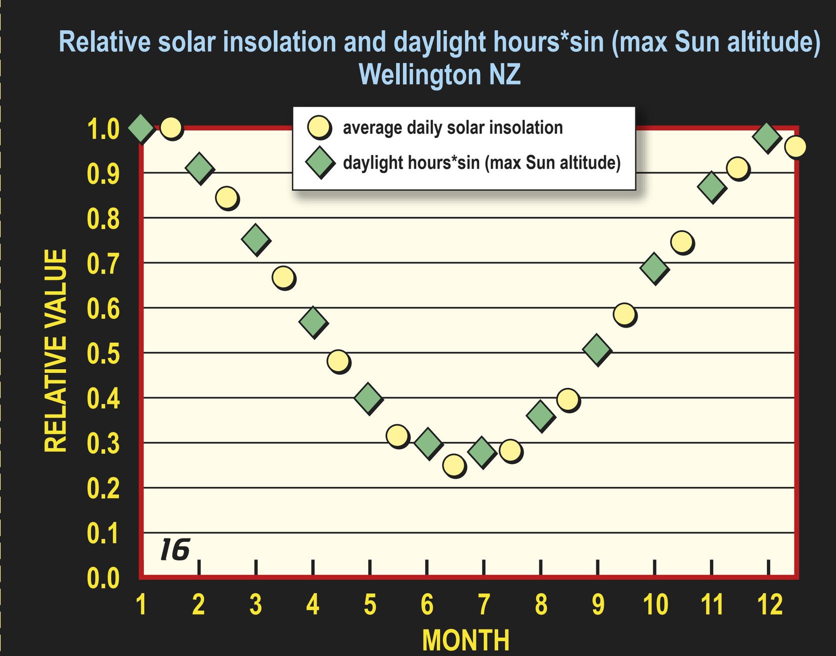












The number of daylight hours and the maximum Sun altitude vary significantly over a year. The maximum Sun altitude varies by 23.5° + 23.5° = 47° annually. We expect the annual variation in the solar energy striking Earth at a location to depend on the number of daylight hours and the sine of the maximum Sun altitude at that location.

The average daily solar insolation and temperature vary significantly over a year.

The yearly variation of the solar insolation is close to but does not exactly follow the variation of the number of daylight hours or the sine of the maximum Sun altitude.

The yearly variation of the solar insolation closely matches the yearly variation in the product of the number of daylight hours and sine of the maximum Sun altitude.

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