**Title:**

**Abstract**

**Introduction**

**Methods**

Version of python:

Python libraries used: numpy, pandas, matplotlib

The sun emits a fairly consistent amount of power outwards in all directions. The amount of power it emits is called solar luminosity (abbreviated as L0 ) and is equal to watts. Solar luminosity is emitted in all directions, and for the purposed of this project, it is necessary to determine the power per area that is transmitted from the sun to the Earth. First, it is useful to picture a giant sphere that surrounds the sun. This imaginary sphere is the perfect size so that Earth is on its surface. If we divide the solar luminosity by the surface area of this sphere (in square meters), then we will be able to know the power per square meter that the sun gives to Earth. The radius of this sphere is equal to the distance of Earth from the sun () plus the radius of the sun (). Therefore, the radius of the imaginary sphere is . Surface area (SA) is equal to , so:

Now that we have the surface area, we can determine the power per square meter that the sun gives to Earth, which is also known as the solar constant and abbreviated with :

This is the first constant I define in my Python script, and I denote it as S0. However, the solar constant assumes that sunlight is striking Earth’s surface directly. In reality, most places on Earth are not faced directly at the sun at any given time, and the angle that the sun’s rays hit Earth changes every minute, hour, day, and with latitude. In addition, the distance between the Earth and sun changes during the summer and winter.

Due to these factors, we cannot simply use the solar constant to represent the power arriving at any spot on Earth at any time. Instead, we have to use the following equation, which includes the solar constant:

where is the mean distance of Earth from the sun, d is the actual distance from the sun at any given moment, and θs is the solar zenith angle. The solar zenith angle is the angle between incoming solar rays and the ground, as represented in this image:



image from Hartman 1994, *Global Physical Climatology*

The solar zenith angle is composed of several parts:

* Latitude
* Declination Angle: the latitude of point ss at noon.
* Hour Angle: the angle between vector Z and the longitude line that contains point ss.

For the sake of readability, variables are defined as follows:

* Latitude: ϕ
* Declination Angle: δ

Using these variables, we can find express the as:

Declination angle is dependent on the time of year, and we must express this angle in radians using the following formula:

Day of the year is abbreviated with dn and then we can use this to find the declination angle with this formula:

The coefficients for this formula are given below:

n an bn

0 0.006918

1 -0.399912 0.070257

2 -0.006758 0.000907

3 -0.002697 0.001480

Now, we must calculate the distance of the Earth from the sun. Using the day of the year, we can calculate the distance ratio as follows:

The coefficients for this formula are given below:

n an bn

0 1.000110

1 0.034221 0.001280

2 0.000719 0.000077

Now we have established the necessary formulas to solve for Q, but the do not take into account the fact that only 75% of the power that reaches the Earth makes it through the atmosphere. Therefore, we must multiply Q by 0.75 to get the actual power arriving at any spot on Earth at any time. The Solar\_Power\_Calculator function uses the math explained above to output the power that reaches the earth at any given place in watts per meter squared.

Using this same math, the function Solar\_Energy\_Calculator uses a ‘for loop’ to calculate Q for every hour of the year. In addition, rather than assuming the area in question is one square meter, this function takes area as an input. It also takes solar panel efficiency as an input. The function then compiles a list of Q for ever hour of the year, which can be graphed as power production over the year. The sum of this list, then, is the amount of energy that the given area of solar panels with the given panel efficiency can produce in a year.

Weather Data

**Results**

**Discussion**

**References**