Air & Surface Temp. and Humidity's Effect on Solar Panels

Jakob Shiffler & Adam Zuccarell

Toledo Technology Academy

Toledo, Ohio

Teachers: Laura Kubiak, Gladwyn Richardson

February 26, 2025

ABSTRACT

For this research project, the objective was to find if surface temperature, air temperature, and humidity affected solar irradiance and solar panel output. All of the data was collected on the roof of the Devilbiss Campus' EV Lab. The hypothesis was that the parameters did have an effect and that the higher the temperature and humidity the lower the solar irradiance and solar panel output. The hypothesis was only partially correct, each variable on its own had a low correlation, but when all of the variables were considered at once the correlation was high.

Central Bold Statement

Air Temperature, Surface Temperature, and Humidity seem to have a minimum effect on Solar Irradiance.

Introduction

How does air temperature, surface temperature, and humidity affect solar irradiance and solar panel output? This is valuable for solar companies and other such groups because it allows one to determine the best locations for solar panels, because if there is an effect and a detrimental one, you might not want a solar panel in that area. Including insights from Jeffrey Hovis, science and operations officer at the National Oceanic and Atmospheric Administration's National and Weather Service, explains that "that humidity describes the amount of water in the air, which varies as part of the cycle of evaporation and condensation." Using this information, it could be concluded that humidity might cause interference with the solar irradiance in the area. As Dr. Manoj Panjwani, contributor to Department of Electronic Engineering, explains, "One of the

effects that we found out after our experimental analysis was of the humidity that it brings down the utilization of solar energy approximately to 55-60% from just 70% approximately of utilized energy." Ultimately reducing the solar panel output. Along with humidity, it could be concluded that air temperature and surface temperature had an impact on solar irradiance; furthermore, affecting the solar panel output.

Hypothesis

As the air temperature, surface temperature, and humidity get higher, the solar irradiance and solar panel output gets lower. This could happen because the water in the air would refract the light, and the heat coming off the solar panel will reflect the light lowering how much could be used.

Objective

The object was to figure out air temperature, humidity, and surface temperature affects solar irradiance, then one can figure out where it would be best to put solar panels.

Methods

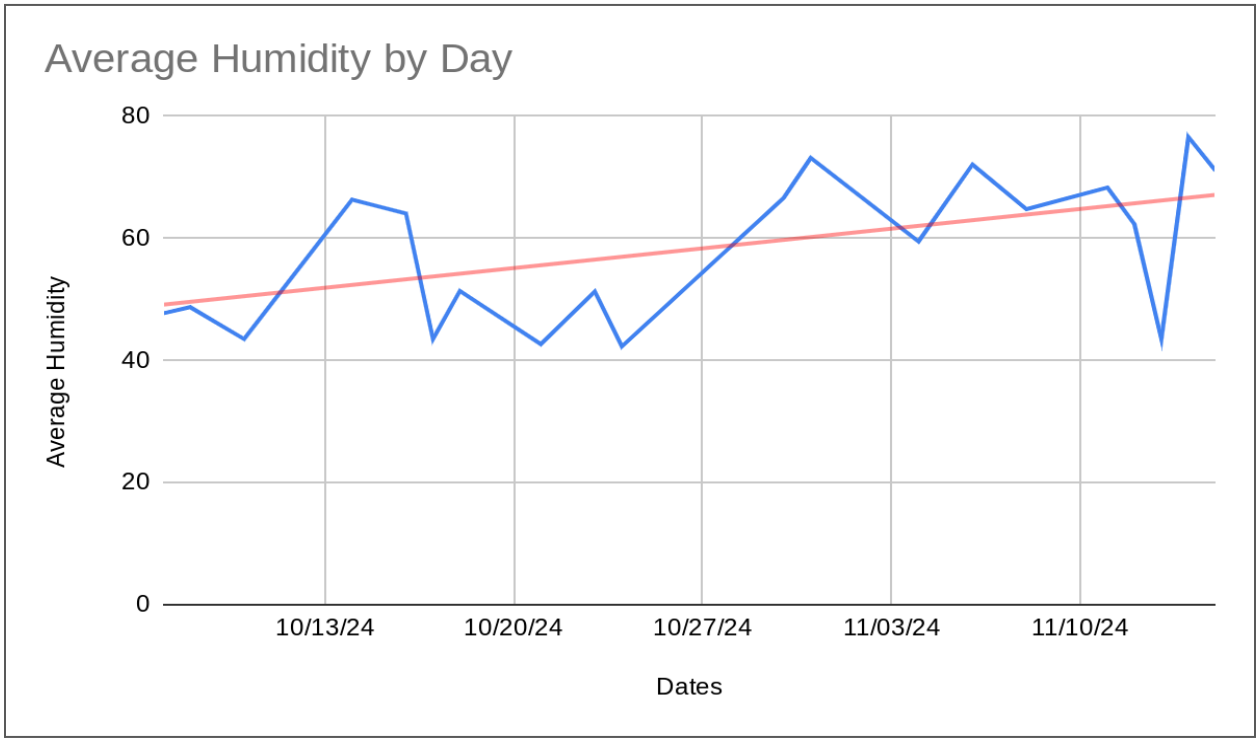
All research was conducted in the TTA EV Lab. The first step was to gather the required PPE, which was hard hats, safety vests, and safety goggles. Then you need to gather the research equipment, which includes the Psychrometer, Pyranometer, infrared thermometer, air temperature probe, and the LabQuest (Model 2 or 3). Then we go onto the roof and record each variable–air temperature, surface temperature, solar irradiance, and humidity–separately, while following the correct procedure, and note down the output in an engineer's notebook. Then

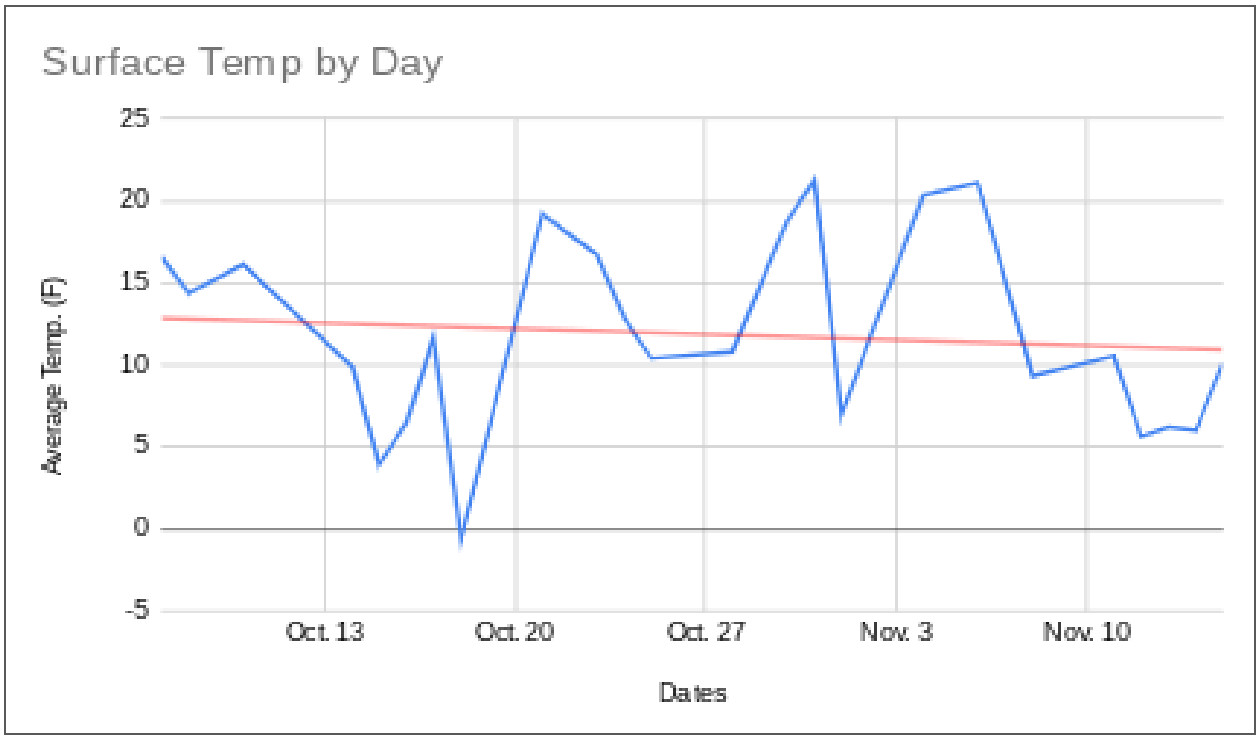
return to the classroom. Next, gather the solar panel output from the APSystems website. Then put every bit of data possible into the GLOBE Website (Humidity, Air Temp., & Surface Temp.). Finally, use the collected data to make graphs using Google Sheets & StatsBlue Website.

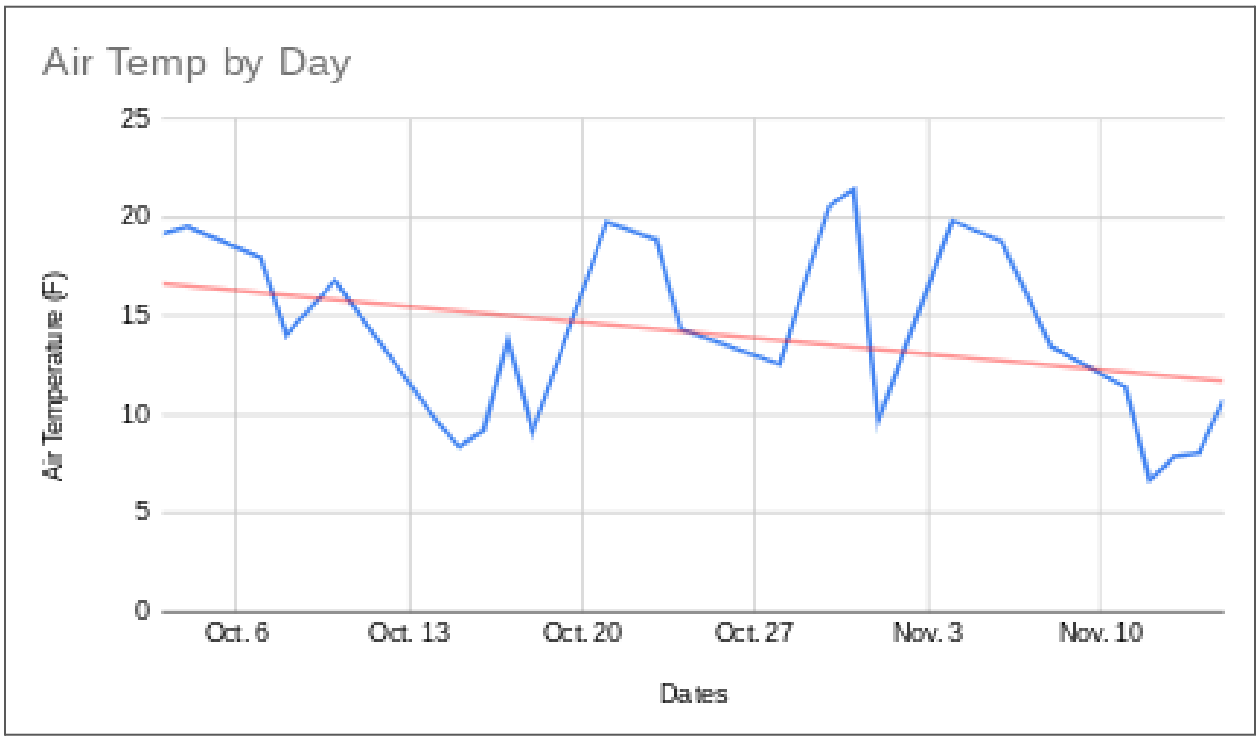
Results

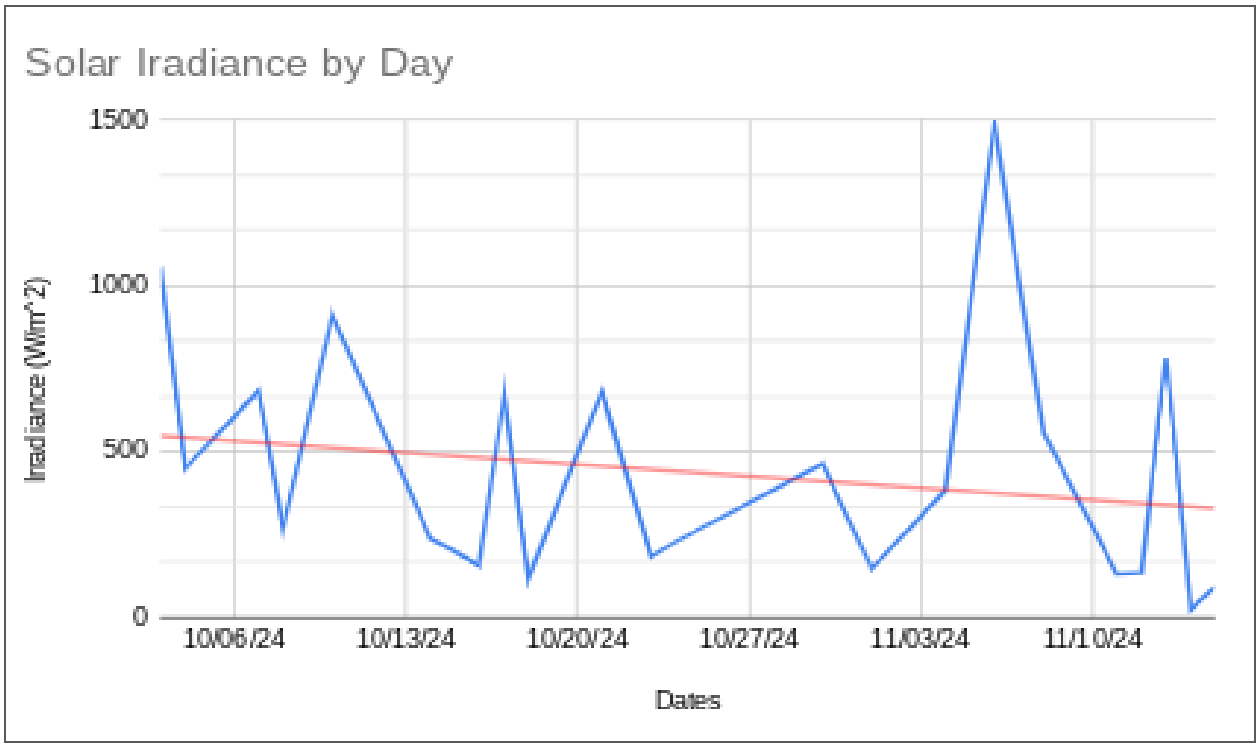
After compiling the data into graphs, as seen in the center panel, as the days went by, surface temperature, air temperature, and solar irradiance lowered, while humidity seemed to rise.

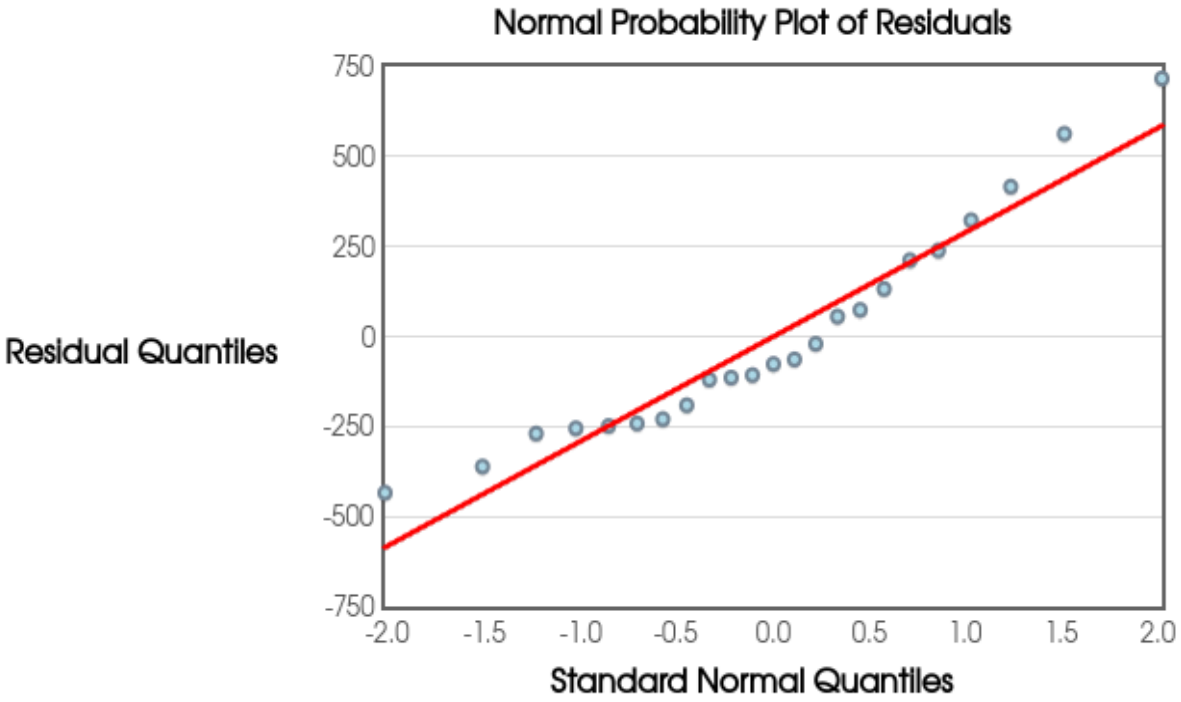
Graphs/Photos/Maps

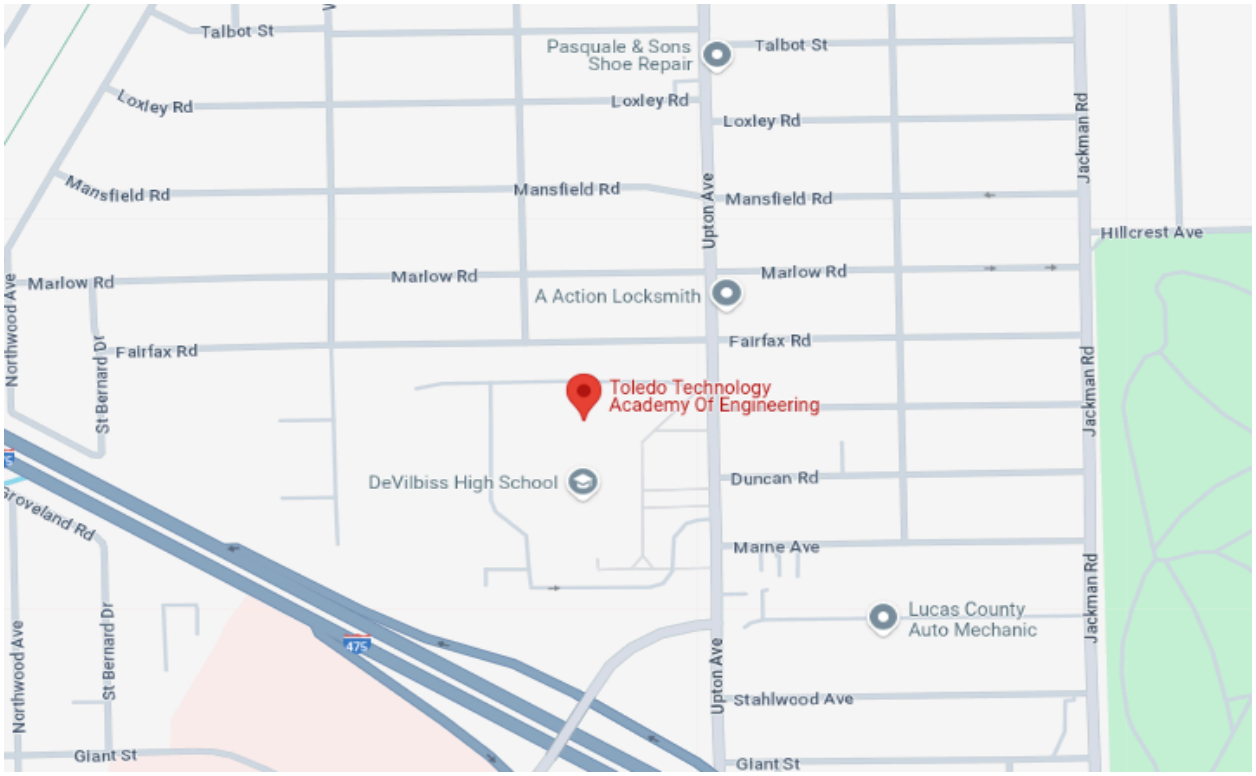


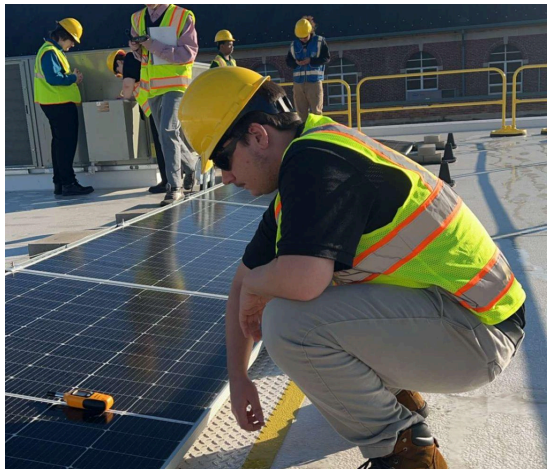

Surface Temp by Day
25
20
15
10
5
0
-5
Average Temp. (F)
Oct. 13
Oct. 20
Oct. 27
Nov. 3
Nov. 10
Dates

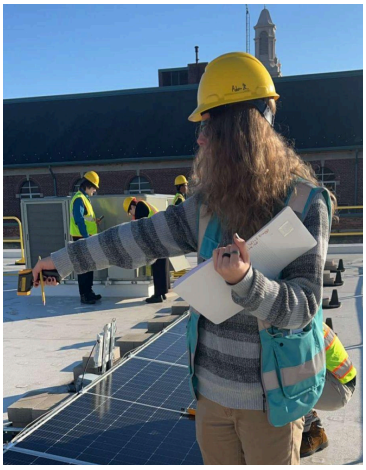

Air Temp by Day
25
20
15
10
5
0
Air Temperature (F)
Oct. 6
Oct. 13
Oct. 20
Oct. 27
Nov. 3
Nov. 10
Dates


Solar Iradiance by Day
1500
1000
500
0
Iradiance (W/m^2)
10/06/24
10/13/24
10/20/24
10/27/24
11/03/24
11/10/24
Dates


Normal Probability Plot of Residuals
Residual Quantiles
750
500
250
0
-250
-500
-750
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Standard Normal Quantiles







From Top-Down, Left-to-right: Individual Variables by day, Compiled variables vs. Solar Irradiance, Map of research location, Image of psychrometer, and images of researchers.

Conclusion

Gathering from the collected data, it can be concluded that the hypothesis was incorrect, as none of the variables had a noticeable effect. Additionally, there were other variables that hadn't been considered, like the sun changing positions based on the time of year. It was considered whether the recorded variables had an effect on the panels themselves, but it was decided that the information wasn't important to this experiment so it wasn't implemented. To help other students in the future, or scientists, one would have to isolate experiments that would have an effect on solar irradiance and solar panel output. One should take into account the sun's direction from the solar panels. An experiment could be conducted where there is an isolated room with a solar panel and the temp, humidity, and other variables could be manually adjusted and controlled.

Badges

I am a Student Researcher

We are currently juniors enrolled at Toledo Technology Academy of Engineering. We are expected to graduate in 2026.

I am a Data Scientist

During our research project, we compiled the data we collected into several graphs indicating the trend at which the variables change. Including making data tables of the individual variables vs. time, we also compared all of the variables at once to the solar irradiance we collected. Using the data tables we had reached several conclusions and wrote about them in both our research paper and poster.

I work with a STEM Professional

Throughout our research, we worked with multiple people who possess a deeper understanding of our project. We talked to a professional from NASA, Geoff Bland. We also have talked to a UT professor and globe enthusiast, Grant Wilson.

Acknowledgements

Laura Kubiak (TPS)–Stuck with us the entire project giving advice the entire time.

Timothy Best (TPS)–Taught us skills and helped with formatting poster.

Grant Wilson (U.T., GLOBE)–Met with us and gave us advice on how to run our project and research.

Geoff Bland (NASA)–Gave advice through video calls about our project and gave us tips for researching.

Gladwyn Richardson (TPS)–Gave us some tips for our research questions.

Kristine Kania (TPS)–Helped us with making the graphs and taught us how to use StatsBlue

References

Bonacci, O. (2022). What is above-average air temperature!? Theoretical & Applied Climatology, 150(1/2), 85–101. https://doi.org/10.1007/s00704-022-04144-y

Climate Change. (2024, September 5). SEIA. https://seia.org/initiatives/climate-change/

Guan, K. (2021). Surface and ambient air temperatures associated with different ground material (University of California, Ed.; pp. 1–14) [Review of Surface and ambient air temperatures associated with different ground material].

HOVIS, J. What causes humidity? Scientific American, [s. l.], v. 294, n. 1, p. 100, 2006. https://research.ebsco.com/linkprocessor/plink?id=e4242634-aad9-368c-952e-388aaa4456

Panjwani, M., Bukshsh Narejo, Dr. G., & Department of Electronic Engineering. (2014). Effect of Humidity on the Efficiency of Solar Cell [Review of Effect of Humidity on the Efficiency of Solar Cell]. International Journal of Engineering Research and General Science.

U.S. Energy Information Administration. (2022, February 25). Solar energy and the environment. U.S. Energy Information Administration. https://www.eia.gov/energyexplained/solar/solar-energy-and-the-environment.php

Senger, G., Chtirkova, B., Folini, D., Wohland, J., & Wild, M. (2024). Persistent Extreme Surface Solar Radiation and Its Implications on Solar Photovoltaics. Earth's Future, 12(8). https://doi.org/10.1029/2023EF004266