How Do Cloud Type and Coverage Affect Our Solar Panels?

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Introduction

Our project is: How does cloud type and coverage affect our solar panels? In their 2024 study published in *Renewable Energy: An International Journal*, Franklin W. Watt and Paul A. Campbell examine how solar insolation and cloud opacity influence the optimal array size for direct-coupled solar pumping systems. They note that "solar energy has the disadvantage of being intermittent and unpredictable," yet highlight that "photovoltaic water pumping (PVWP) also ensures additional energy security when compared to pumping systems driven by conventional energy sources." This underscores the potential of PVWP systems to enhance energy security despite the inherent variability of solar energy.

Hypothesis

Cloud Coverage is assumed to affect the output, but we think cloud type will also heavily affect our panels.

Objective

It is essential to forecast solar energy production for any given day without relying on a solar irradiance meter.

Methods

Study Focus: Investigated the impact of cloud coverage and cloud type on solar panel performance.

Data Collection Methods:
- Method 1: Captured images using a mini camera attached to a kite.
- Method 2: Took ground-level photographs with an iPad and transmitted them to a global platform.

Solar Data Collection:
- Obtained from a dedicated solar website that connects to our solar panels.

Data Organization:
- Systematically organized data into Google Sheets.
- Generated graphs to visually represent findings.
- Cloud Coverage Measurement:
- Used the Globe app and the grid method for data points.

Data Point Note:
- Only one data point for air pictures (1/18) due to instrument loss during flight caused by weather.

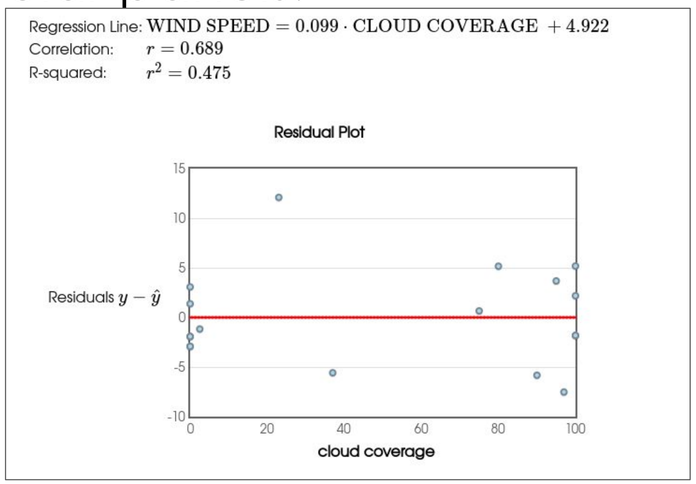
Graph Creation:
- Data was entered into the StatsBlue website to create the corresponding graphs.

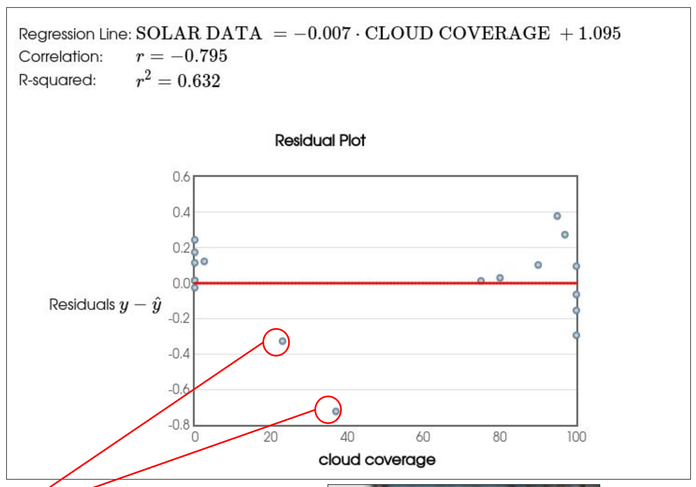
Cloud type and coverage affect our solar panels.

Aeropod being used to get sky info

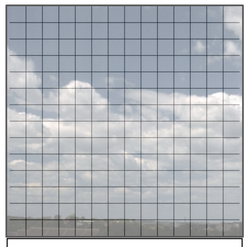
Area of launch and data collection

Dylan collecting data

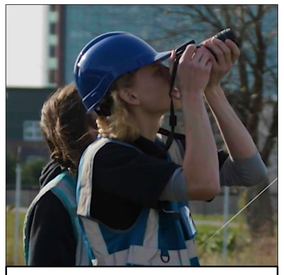




flight	solar output kilowatts	cloud coverage	wind speed mph	cloud type	temperature	flight height
Oct 8 no	0.1005		37 3 mph	cirrus	54 F	na
Oct 9 no	1.34		0 3 mph	none	46 F	na
Oct 10 no	1.27		0 2 mph	none	51 F	na
Oct 11 no	1.2		2.5 4 mph	strays streams	51 F	na
Oct 14 yes	0.66		97 7 mph	cumulus	54 F	346 ft
Oct 15 yes	0.54		90 8 mph	stratus	40 F	350 ft
Oct 16 no	1.11		0 6.3 mph	none	60F	na
Oct 17 no	1.21		0 3 mph	none	60 F	na
Oct 23 yes	1.07		0 8 mph	none	60F	376 ft
Oct 23 no	0.6		23 19.3 mph	cirrostratus and altocumulus	66-44	na
Oct 24 no	1.11		0 2 mph	none	53F	na
Oct 30 YES kite gone	0.78		95 18 mph	all	58F	10000000000 ft
Oct 31 no no kite	0.21		100 20 mph	all	70	na
Nov 1 no no kite	0.56		75 13 mph		68	na
Nov 4 no no kite	0.46		100 13 mph	stratus	67F	na
Nov 6 no	0.54		80 18 mph	low	63F	na
Nov 11 yes	0.3		100 17 mph	altostratus and stratocumulus	57F	380 ft
Nov 14 yes	0.07		100 13 mph	Cumulonimbus and Nimbostratus	49F	120 ft



Grid method of getting cloud coverage



Dalton collecting cloud coverage data

Abstract

In this research, we explored how cloud coverage and cloud type influence the efficiency of our solar panels. To collect cloud data, we utilized two different approaches: the first method involved using a mini camera mounted on a kite to capture images, while the second method entailed taking ground-level photographs with an iPad and uploading them to a global platform. The solar data was exclusively sourced from a specialized website that connects with our solar panels. We meticulously arranged these data points in a Google Sheet and created visual graphs to illustrate our results.

Results

We conclude (using the graphs on the left) that the cloud coverage definitely has an affect on our solar panels. The type also has an effect, but due to not being able to separate the clouds and isolate them to take measurements, it was hard to pinpoint which clouds were affecting the panels the most but overcast was the most effective on our panels.

Conclusion

The graphs that were created proved our hypothesis—that the cloud type and coverage would affect our solar panels—true. If we had more time, my group would take the next steps of taking more time with our kite flying and documenting our kite data more accurately.

Our message of hope is that solar panel technology is advancing and becoming more efficient getting rid of some of those problems that make solar panels worse than non-renewable energy.

Acknowledgments

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References

Watt, F. W., & Campbell, P. A. (2024). The effects of solar insolation and cloud opacity on the optimum array size for a direct-coupled solar pumping system. Renewable Energy: An International Journal, 228, N.PAG. https://doi.org/10.1016/j.renene.2024.120594

Zhou, X., Liu, Y., Shan, Y., Endo, S., Xie, Y., & Sengupta, M. (2024). Influences of Cloud Microphysics on the Components of Solar Irradiance in the WRF-Solar Model. Atmosphere, 15(1), 39. https://doi.org/10.3390/atmos15010039

KOSMOPOULOS, P. et al. Multi-Layer Cloud Motion Vector Forecasting for Solar Energy Applications. Applied Energy, [s. l.], v. 353, p. N.PAG, 2024. DOI 10.1016/j.apenergy.2023.122144. Disponível em: https://research.ebsco.com/linkprocessor/plink?id=0b432af2-48e9-3c0b-858f-044850d1111f. Acesso em: 25 set. 2024.

Deo, R. C., Ahmed, A. A. M., Casillas-Pérez, D., Pourmousavi, S. A., Segal, G., Yu, Y., & Salcedo-Sanz, S. (2023). Cloud cover bias correction in numerical weather models for solar energy monitoring and forecasting systems with kernel ridge regression. Renewable Energy: An International Journal, 203, 113–130. https://doi.org/10.1016/j.renene.2022.12.048