Project 1 Appendix

Sanskriti Purohit & Caleb Woo

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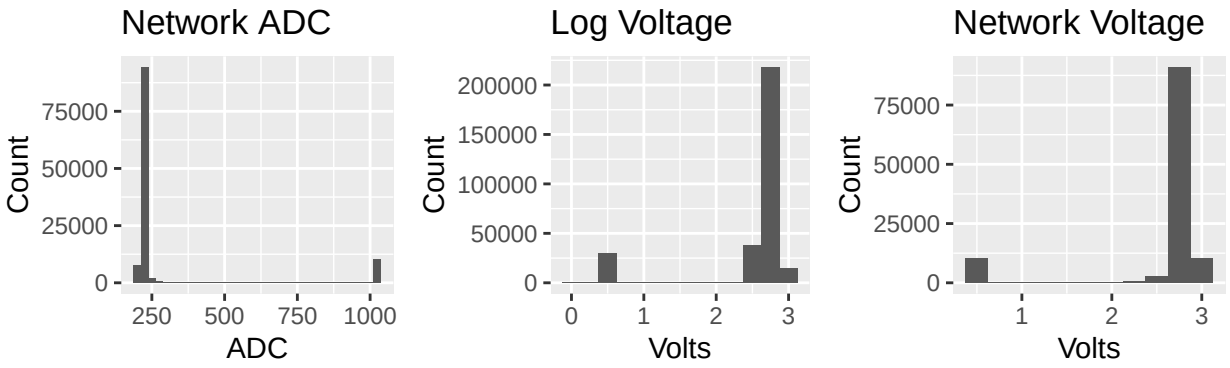
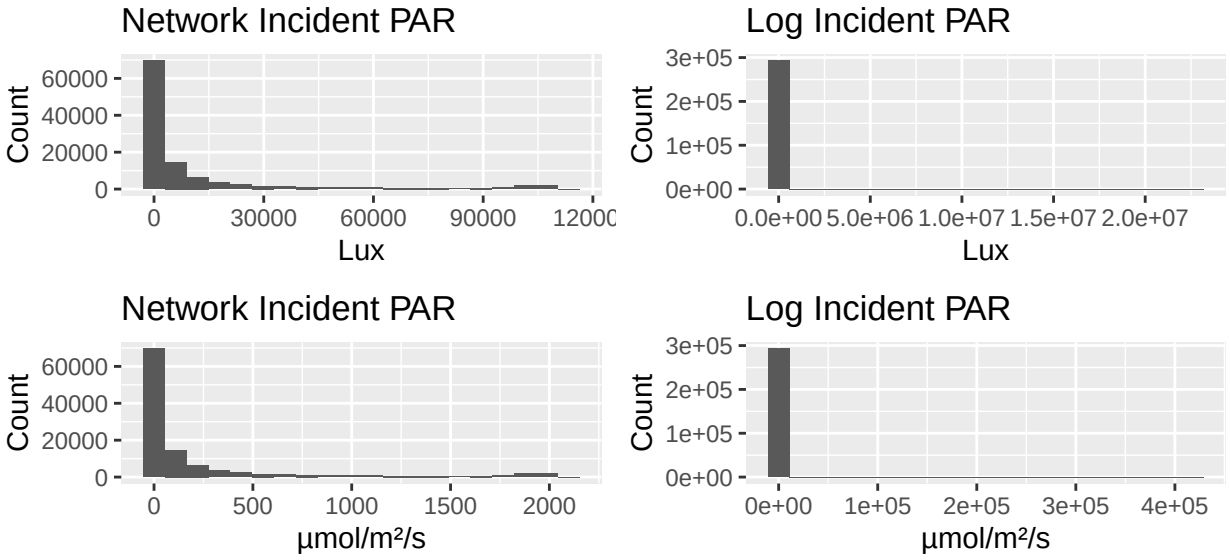
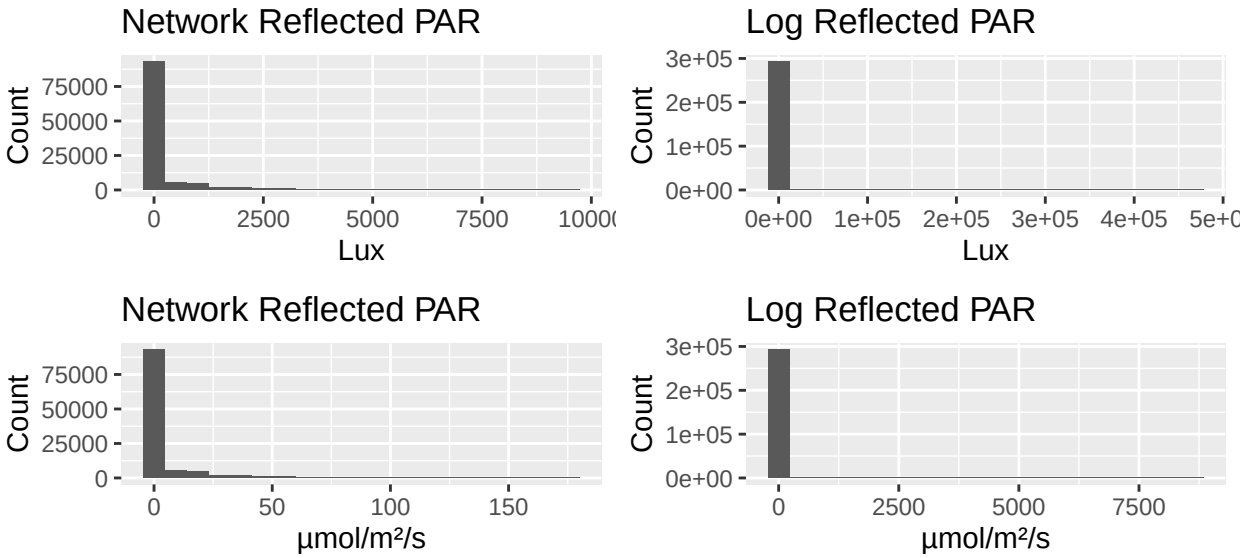
A.1: Voltage Before and After Conversion



A.2: Network and Log Incident PAR Unit Conversion



A.3: Network and Log Reflected PAR Unit Conversion



A.4: Missing Observations

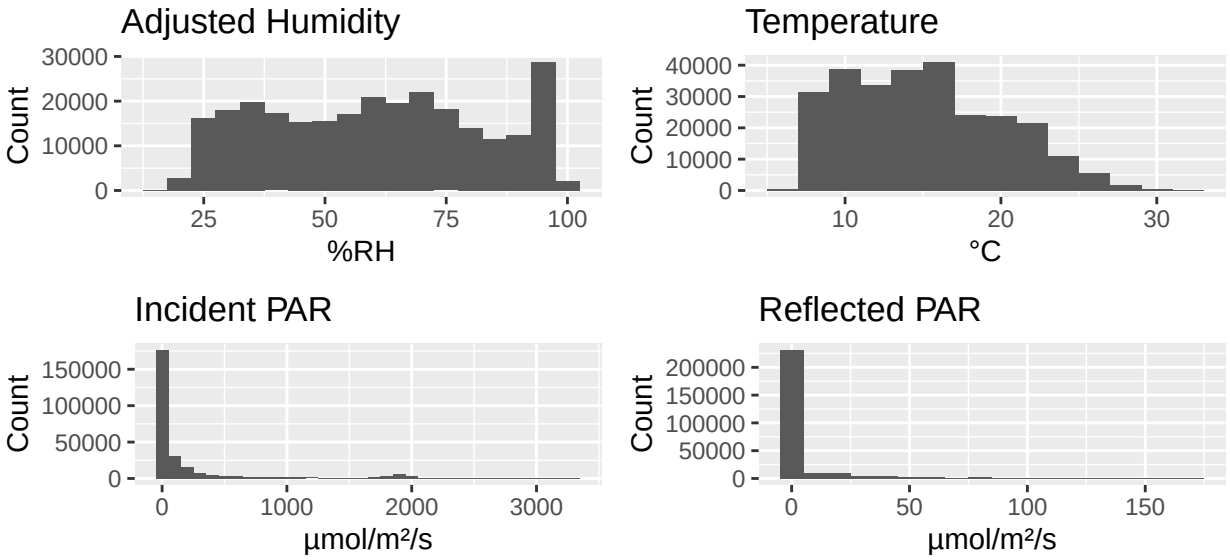
Table 1: 8760 Missing Observations Time Period

Start	End
2004-04-30 08:05:00	2004-05-25 21:15:00

A.5: Quantiles and Histograms After Removing Voltages

Table 2: Quantiles After Removing Outlier Voltages

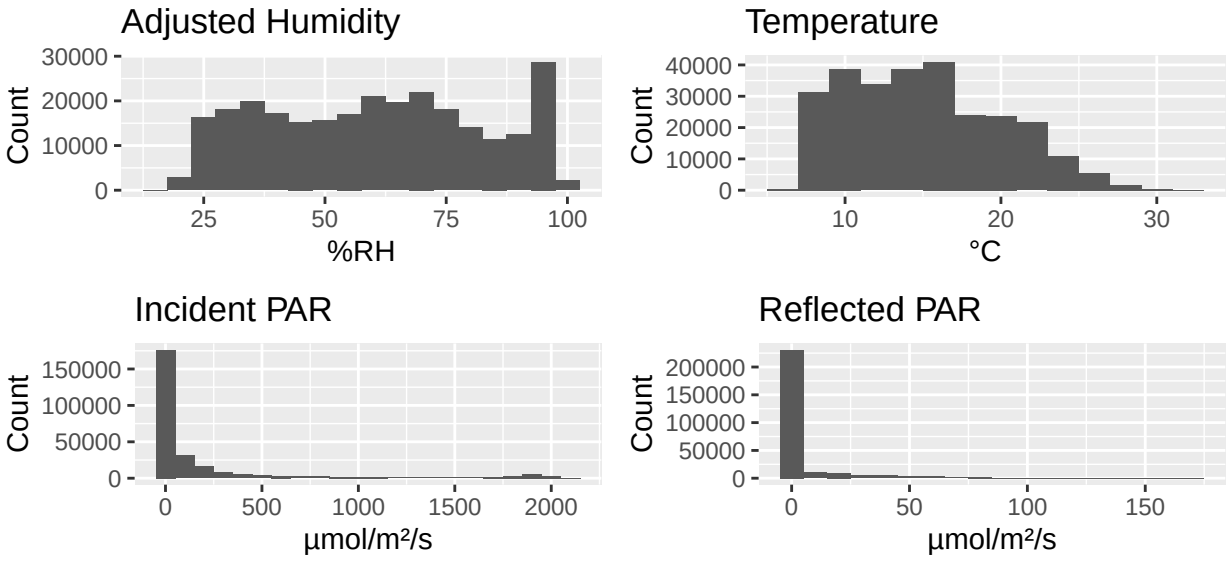
	Humidity	Adjusted Humidity	Temperature	Incident PAR	Reflected PAR
0%	16.265	16.228	6.582	0.000	0.000
25%	41.074	40.581	10.796	0.000	0.000
50%	62.453	60.781	14.579	0.000	0.000
75%	80.805	77.786	18.616	132.848	0.000
100%	104.405	100.223	32.581	3334.717	169.143



A.6: Quantiles and Histograms After Removing Node 40

Table 3: Quantiles After Removing Node 40

	Adjusted Humidity	Temperature	Incident PAR	Reflected PAR
0%	16.228	6.582	0.000	0.000
25%	40.598	10.796	0.000	0.000
50%	60.794	14.579	0.000	0.000
75%	77.794	18.607	132.218	0.000
100%	100.223	32.581	2068.670	169.143



A.7: Creating the Time Period Variable

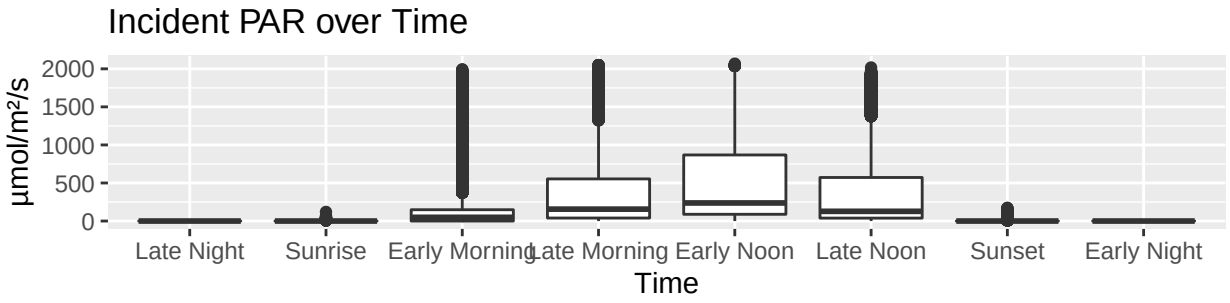
Since the data contains so many different time stamps per day, we wanted to look at bigger periods of time to see if there are any noticeable differences in humidity, temperature, incident PAR, and reflected PAR between the time periods. In order to do so, we wanted to split each day into different time periods based on the sunrise and sunset times. We web scraped the sunrise, sunset, civil twilight, and solar noon times of all 31 days from May, 2004 in Sonoma, California. Observations from May 1, 2004 to May 31, 2004 makes about 78.2% of our total data so working with only May data still accounts for most of our total cleaned data. After web scraping and merging the scraped sun data with our May data, we assigned each observation a time period out of 8 categories: sunrise, sunset, early morning, late morning, early noon, late noon, early night, and late night.

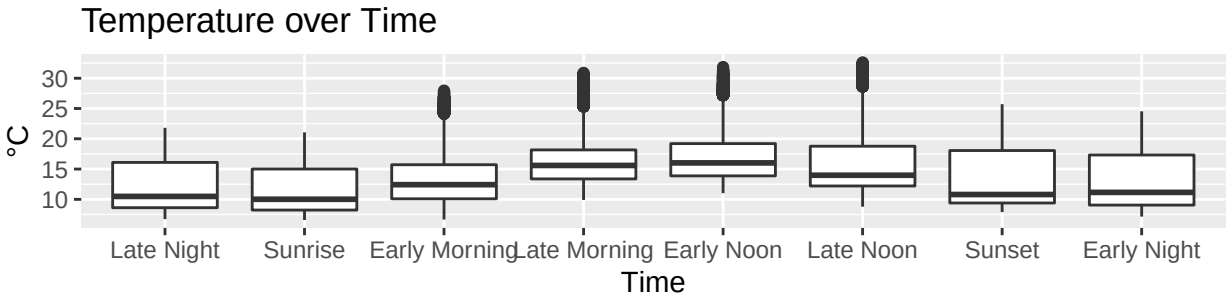
We assigned sunrise as the time period from the start of civil twilight to the number of minutes after sunrise that it took between the start of civil twilight to sunrise. For example, for May 1, civil twilight starts at 5:44 AM and sunrise occurs at 6:12 AM. Since it took 28 minutes between the start of civil twilight to sunrise, we made the end of sunrise 28 minutes after sunrise. So our sunrise time period for May 1 was 5:44 AM to 6:40 AM. Our sunrise time period varies by the start of civil twilight time and sunrise time for that day.

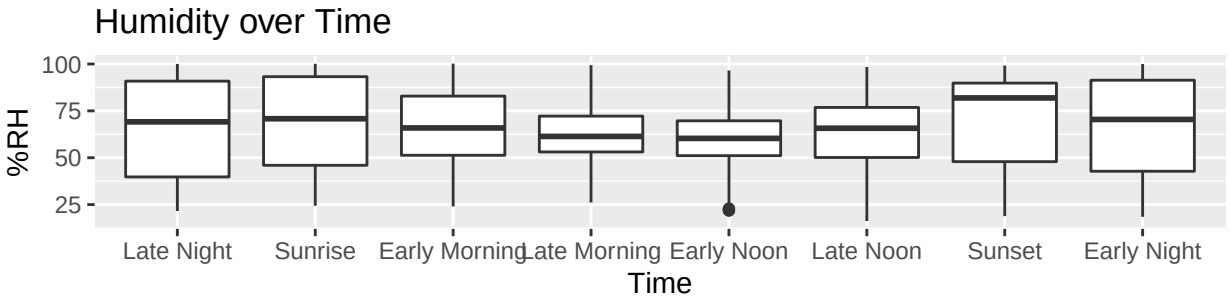
We assigned sunset as the time period from the number of minutes before sunset it took between sunset to the end of civil twilight to the end of civil twilight. For example, for May 1, civil twilight ends at 8:30 PM and sunset occurs at 8:01 PM. Since it took 29 minutes between sunset to the end of civil twilight, we made the start of sunset 29 minutes before sunset. So our sunset time period for May 1 was 7:32 PM to 8:30 PM. Our sunset time period varies by the end of civil twilight time and sunset time for that day.

The remaining time periods fill in quite naturally. Early morning is the time period from the end of sunrise as defined above to 10:00 AM. Late morning is the time period from 10:00 AM to the solar noon time of that day. Early noon is the time period from the solar noon time of that day to 4:30 PM. Late noon is the time period from 4:30 PM to the beginning of sunset time as defined above. Early night is the time period from the end of sunset time as defined above (end of civil twilight time) to 1:30 AM of the next day. Late night is the time period from 1:30 AM to the beginning of sunrise time as defined above (start of civil twilight time).

Looking at the box plots of incident PAR, temperature, and humidity over these time periods, shown below, revealed some general trends that are confirmed by the paper. Both incident PAR and temperature start low and gradually increase before peaking at noon and gradually decreasing which suggests that these two measurements follow the normal movement of the sun as confirmed by Tolle et al. Humidity on the other hand starts high and gradually decreases before hitting its lowest point at noon and gradually increasing which suggests that humidity moves inversely with temperature which Tolle et al. alludes to. We also see that variability is reduced once the sun has risen and humidity has decreased which is confirmed by the paper's finding that temporal variability is reduced once the sun has risen. Since our box plots over our newly defined time periods reveal similar trends to that of the paper, we are fairly confident in how we split up our observations over time periods. Next, we used these newly defined time periods with GMM clustering to reveal further trends.


Incident PAR over Time
µmol/m²/s
2000
1500
1000
500
0
Late Night
Sunrise
Early Morning
Late Morning
Early Noon
Late Noon
Sunset
Early Night
Time


Temperature over Time
°C
30
25
20
15
10
Late Night
Sunrise
Early Morning
Late Morning
Early Noon
Late Noon
Sunset
Early Night
Time


Humidity over Time
%RH
100
75
50
25
Late Night
Sunrise
Early Morning
Late Morning
Early Noon
Late Noon
Sunset
Early Night
Time