The effect of air pollution on space imagery

Planet Photos taken by Kush Gulati

This project's main purpose is to find out if air pollution has an impact on images of space taken by a telescope. This would be experimented by comparing the AQI(Air Quality Index) and the IQS (Image Quality Score).

Background Research on Air pollution's effect on telescopic images

- I became generally interested in astronomy and space science through reading "Astronomy magazine" and other related text
- I came to understand that telescopes put in space such as the Hubble telescope, Kepler telescope have significant limitations in how large a part of the sky that they can monitor at a time.
- Here in the comfort of the Earth's a telescope can be set up very easily and be pointed to various parts of the sky with ease.
- However, the earth's atmosphere creates aberrations in space images.
- I wanted understand the correlation between air pollution and the quality of space images.

Information about the project

My hypothesis is If there is more air pollution (particulate matter in the atmosphere), then the images taken by the telescope will be of worse quality.

- My Control variable is the average Image quality score (IQS) of images taken on the day of lowest level of pollution.
- My Independent variable is the AQI (Air Quality Index) in the area of observation.
- My dependent variable is the image quality score (IQS)
- I used:
  - A Celestron Nexstar 5se telescope
  - Canon EOS Rebel T7i camera
  - AutoStakkert software
  - Backyard EOS software
  - PIPP software

Procedures

1) Setup the Celestron Nexstar 5SE.

- Align the telescope to the north star.
- Calibrate telescope.
- Point telescope to the subject space object.

2) Attach camera to the telescope.

- I attached the camera to the telescope with a T-ring and sometimes a Barlow lens.

3) Capture several images of the subject space object for different camera settings.

- In this step I changed the ISO Gain and the shutter speed to get a variety of images of the subject space object.

4) Calculate image quality score for each space object and average across that day.

5) Analyze images

The Images were analyzed using a software called auto stakkert.

6) Take Air quality reading for Naples area

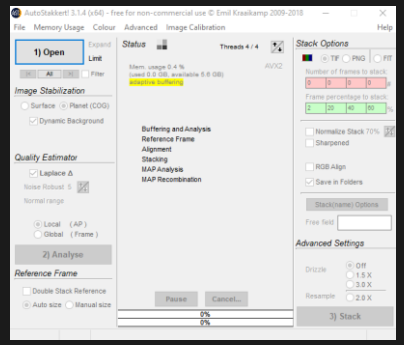
- This Website was used to find the AQI readings:

Repeat steps 1 thru 6 on several days

(Subject space objects are: Mars, Saturn, Jupiter, Moon.)

7) Conduct research on how to save the details lost in the images because of pollution.

Procedures (Continued)



AutoStakkert software

How the average IQS was calculated

IQS_{Moon}

IQS_{Mars}

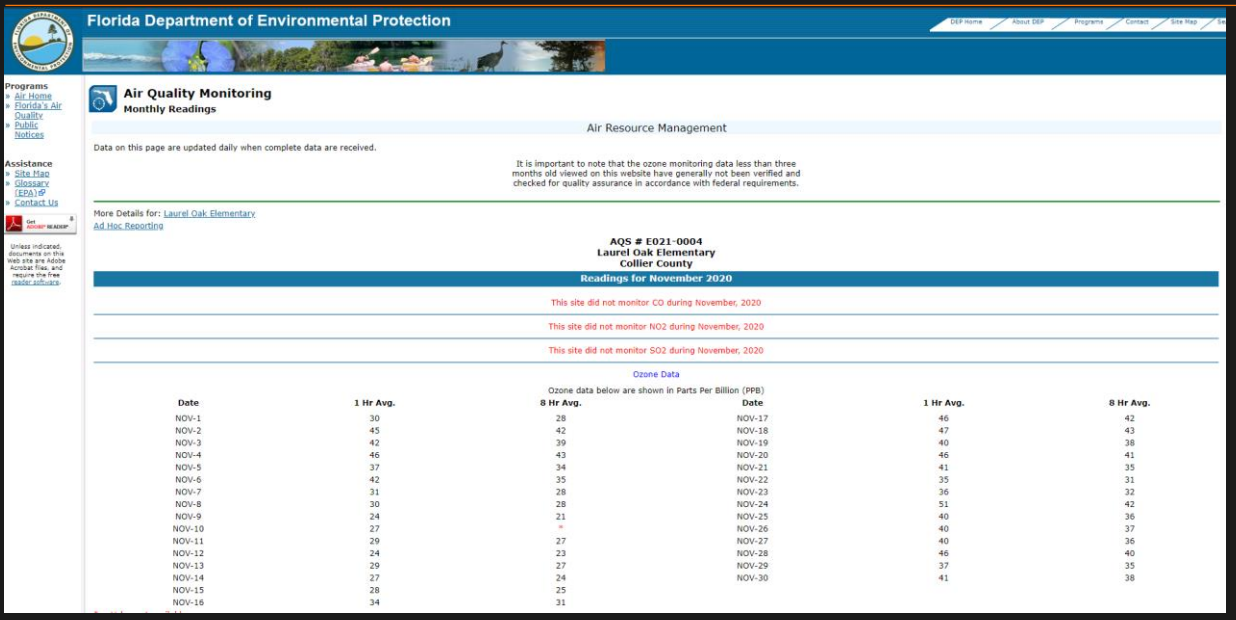
$IQS_{Jupiter}$

IQS_{Saturn}

Average IQS

How the AQI was calculated

= The AQI for the day



Florida Department of Environmental Protection

Air Quality Monitoring
Monthly Readings

Air Resource Management

Data on this page are updated daily when complete data are received.

It is important to note that the ozone monitoring data less than three months old viewed on this website have generally not been verified and checked for quality assurance in accordance with federal requirements.

More Details for: Laurel Oak Elementary
Ad Hoc Reporting

AQS # E021-0004
Laurel Oak Elementary
Collier County

Readings for November 2020

This site did not monitor CO during November, 2020

This site did not monitor NO2 during November, 2020

This site did not monitor SO2 during November, 2020

Ozone Data

Ozone data below are shown in Parts Per Billion (PPB)

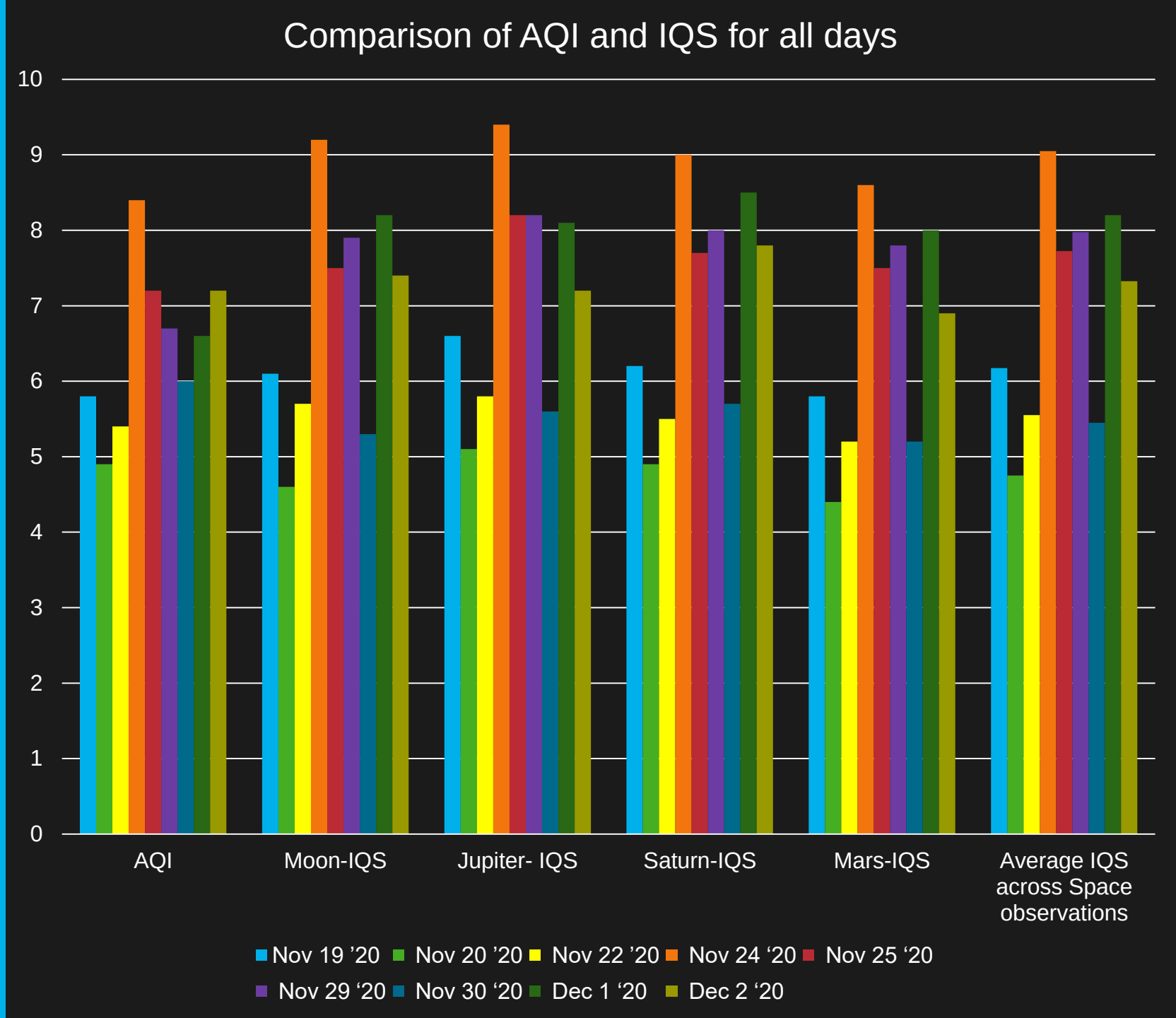
Date	1 Hr Avg.	8 Hr Avg.	Date	1 Hr Avg.	8 Hr Avg.
NOV-1	30	28	NOV-17	46	42
NOV-2	45	42	NOV-18	47	43
NOV-3	42	39	NOV-19	40	38
NOV-4	46	43	NOV-20	46	41
NOV-5	37	34	NOV-21	41	35
NOV-6	42	35	NOV-22	35	31
NOV-7	31	28	NOV-23	36	32
NOV-8	30	28	NOV-24	51	42
NOV-9	24	21	NOV-25	40	36
NOV-10	27	*	NOV-26	40	37
NOV-11	29	27	NOV-27	40	36
NOV-12	24	23	NOV-28	46	40
NOV-13	29	27	NOV-29	37	35
NOV-14	27	24	NOV-30	41	38
NOV-15	28	25			
NOV-16	34	31			

Florida Department of Environmental Protection website

All images on this slide have been taken by Kush Gulati

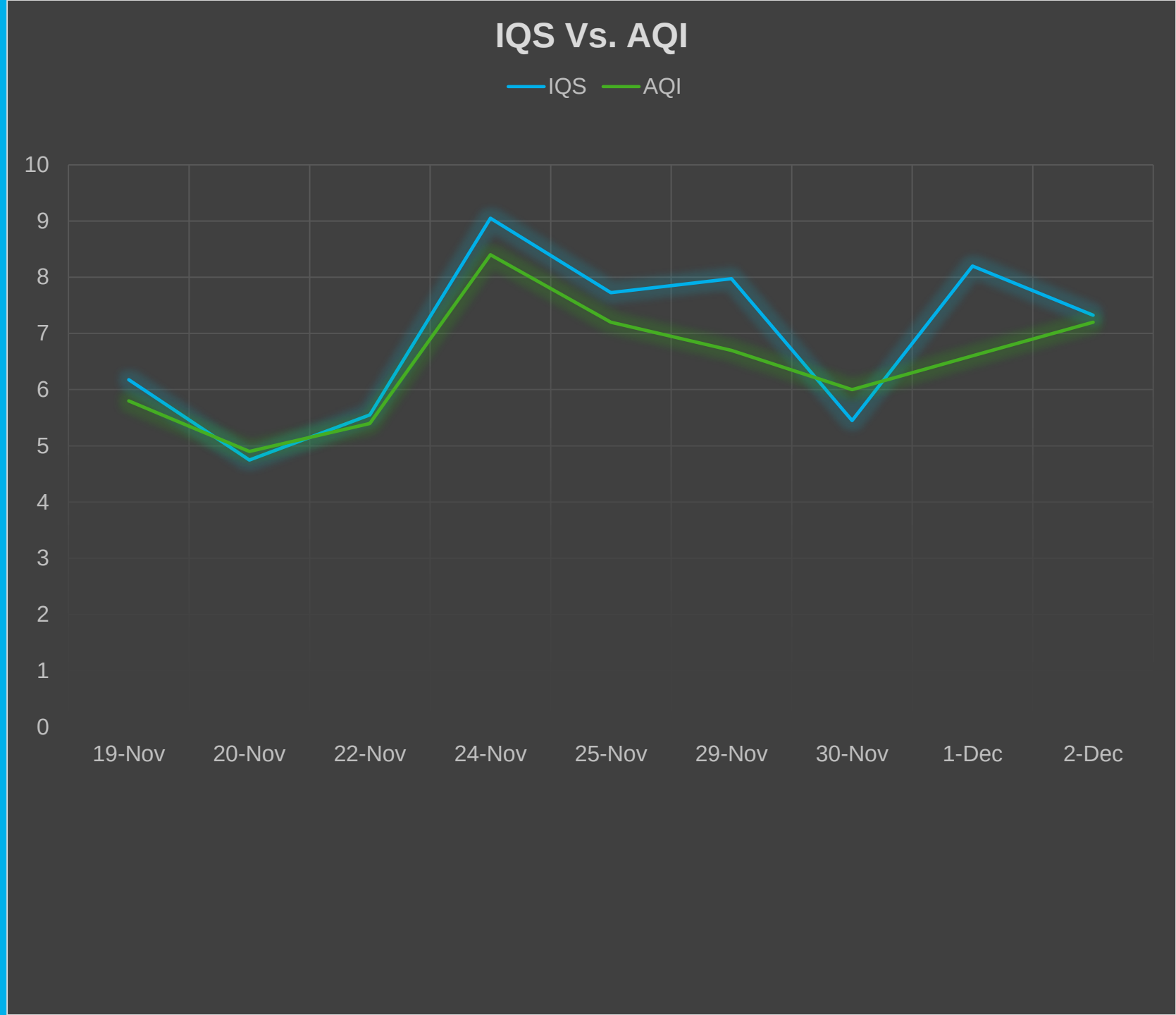
Data/Observations

- The data on the right shows the different IQS of the images taken each day of space observation
- The different colors represent different days of observation
- The first column of the graph shows the AQI of the different days
- The columns in the middle show the Image Quality Scores for each planet
- The last column shows the average IQS across space observations.



Data Observations (continued)

- The data on the right shows that the comparison of the IQS average and the AQI of each day.
- The chart's scale only goes up to ten for simplicity
- The green line represents the AQI
- The blue line represents the IQS
- This is basically an average taken from the data on the previous slide.



Conclusion

It was proven that there was some interference in image quality from air pollution.

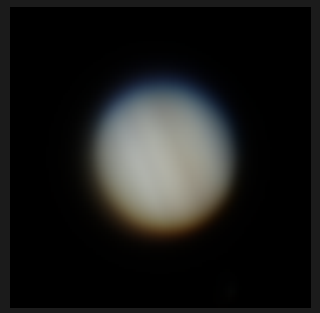
Light pollution is assumed to remain nearly constant through the observation period. Varying wind speed may have also caused refractive shaking in images captured but the PIPP software countered it.

Space based telescopes are better because they take higher quality photos of planets because they don't have to deal with air pollution.

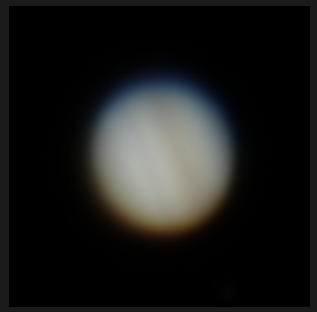
Air Quality changes when there is more particulate matter in the air. When there is more particulate matter in the air then the AQI goes up. The amount of particulate matter in the air is controlled by carbon dioxide emissions and waste of all kinds.

Sample Planetary Images

Jupiter

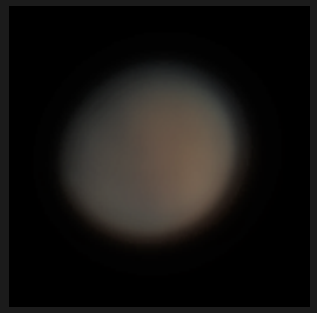


Low IQS observation



High IQS observation

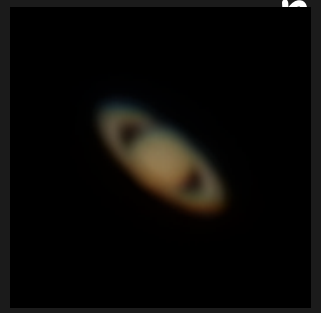
Mars



Low IQS observation

High IQS observation

Saturn



Low IQS observation

High IQS observation

Images on this slide have been taken by Kush Gulati

Works Cited

- Tips on how to image space objects [E-mail interview]. (2020, November/December).
- *Celestron Nexstar 5SE Manual* (5SE ed., Vol. 1, Nexstar). (n.d.).
- Bracken, C. (2017). *The deep-sky imaging primer* (2nd ed., Vol. 1). United States?: Publisher not identified.
- *Canon EOS Rebel T7i Manual* (T7i ed., Vol. 1, Rebel). (n.d.).
- Sanchez, J. (2018). *Space Image Processing* (1st ed., Vol. 1). Taylor & Francis.
- Collier Regional Science & Engineering Fair 2020-2021 Rule Book. (2020). Retrieved January 17, 2021, from https://www.collierschools.com/cms/lib/FL01903251/Centricity/Domain/223/COLLIER%20Rule%20Book%20SY21.pdf

Data Notebook

November 19th, 2020

Date: November 19, 2020

AQI: 5.8

				Image Taken?	Quality Score
Jupiter					
ISO Gain	800	Shutter	1/125s	✓	6.51
ISO Gain	400	Shutter	1/160s	✓	6.72
ISO Gain	800	Shutter	1/500s	✓	6.57
Saturn					
ISO Gain	400	Shutter	1/20s	✓	5.98
ISO Gain	200	Shutter	1/10s	✓	6.45
ISO Gain	100	Shutter	1/80s	✓	5.32
Mars					
ISO Gain	400	Shutter	1/80s	✓	5.98
ISO Gain	800	Shutter	1/250s	✓	5.32
ISO Gain	400	Shutter	1/100s	✓	6.1
Moon					
ISO Gain	200	Shutter	1/400s	✓	5.96
ISO Gain	200	Shutter	1/320s	✓	6.01
ISO Gain	100	Shutter	1/125s	✓	6.33

Data Notebook (continued)

November 20th, 2020

Date: November 20, 2020
AQI: 4.9

				Image Taken?	Quality Score
Jupiter					
ISO Gain	800	Shutter	1/125s	✓	5.06
ISO Gain	400	Shutter	1/160s	✓	5.23
ISO Gain	800	Shutter	1/500s	✓	5.01
Saturn					
ISO Gain	400	Shutter	1/20s	✓	4.69
ISO Gain	200	Shutter	1/10s	✓	5.18
ISO Gain	100	Shutter	1/80s	✓	4.18
Mars					
ISO Gain	400	Shutter	1/80s	✓	4.83
ISO Gain	800	Shutter	1/250s	✓	4.18
ISO Gain	400	Shutter	1/100s	✓	4.19
Moon					
ISO Gain	200	Shutter	1/400s	✓	~~5.72~~ 4.72
ISO Gain	200	Shutter	1/320s	✓	4.58
ISO Gain	100	Shutter	1/125s	✓	4.5

November 22nd,2020

Date: November 22, 2020
AQI: 5.4

				Image Taken?	Quality Score
Jupiter					
ISO Gain	800	Shutter	1/125s	✓	5.68
ISO Gain	400	Shutter	1/160s	✓	5.92
ISO Gain	800	Shutter	1/500s	✓	5.01
Saturn					
ISO Gain	400	Shutter	1/20s	✓	5.82
ISO Gain	200	Shutter	1/10s	✓	5.18
ISO Gain	100	Shutter	1/80s	✓	4.18
Mars					
ISO Gain	400	Shutter	1/80s	✓	5.32
ISO Gain	800	Shutter	1/250s	✓	4.89
ISO Gain	400	Shutter	1/100s	✓	4.19
Moon					
ISO Gain	200	Shutter	1/400s	✓	5.52
ISO Gain	200	Shutter	1/320s	✓	5.8
ISO Gain	100	Shutter	1/125s	✓	4.5

November 24th, 2020

Date: November 24, 2020
AQI: 8.4

				Image Taken?	Quality Score
Jupiter					
ISO Gain	800	Shutter	1/125s	✓	9.56
ISO Gain	400	Shutter	1/160s	✓	9.29
ISO Gain	800	Shutter	1/500s	✓	~~9.21~~ 9.35
Saturn					
ISO Gain	400	Shutter	1/20s	✓	8.89
ISO Gain	200	Shutter	1/10s	✓	9.71
ISO Gain	100	Shutter	1/80s	✓	~~9.45~~ 7.45
Mars					
ISO Gain	400	Shutter	1/80s	✓	9.05
ISO Gain	800	Shutter	1/250s	✓	7.45
ISO Gain	400	Shutter	1/100s	✓	9.3
Moon					
ISO Gain	200	Shutter	1/400s	✓	9.13
ISO Gain	200	Shutter	1/320s	✓	9.26
ISO Gain	100	Shutter	1/125s	✓	~~9.4~~ 9.21

November 25th, 2020

Date: November 25 2020
AQI: 7.2

				Image Taken?	Quality Score
Jupiter					
ISO Gain	800	Shutter	1/125s	✓	8.36
ISO Gain	400	Shutter	1/160s	✓	8.17
ISO Gain	800	Shutter	1/500s	✓	8.07
Saturn					
ISO Gain	400	Shutter	1/20s	✓	7.5
ISO Gain	200	Shutter	1/10s	✓	7.92
ISO Gain	100	Shutter	1/80s	✓	7.59
Mars					
ISO Gain	400	Shutter	1/80s	✓	7.25
ISO Gain	800	Shutter	1/250s	✓	7.59
ISO Gain	400	Shutter	1/100s	✓	7.66
Moon					
ISO Gain	200	Shutter	1/400s	✓	7.72
ISO Gain	200	Shutter	1/320s	✓	7.41
ISO Gain	100	Shutter	1/125s	✓	7.37