Eclipses of a Lifetime

Ashwin, Bruno, Jacob, and Parvati

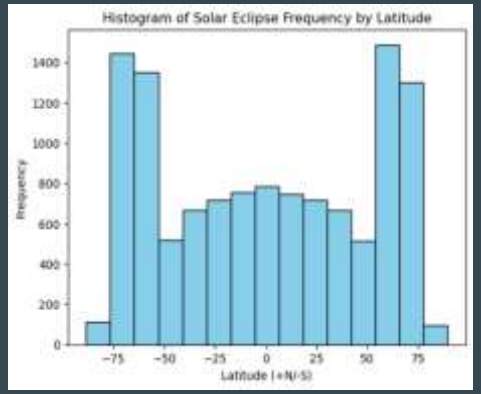
Background

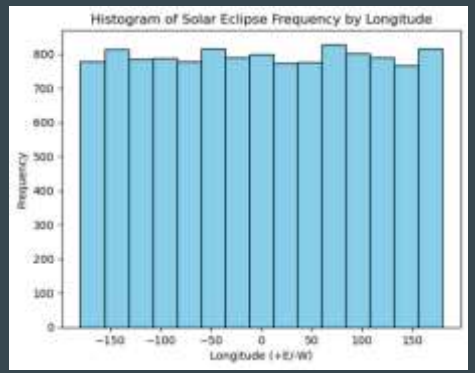
- Eclipses are astronomical phenomena where celestial bodies align
- Solar eclipses occur when the moon obstructs light from the sun to the Earth
  - Can be partial, annular, hybrid, or total eclipses
  - Total solar eclipses are so rare that people travel long distances to view them in person
- Lunar eclipses occur when the Earth obstructs light from the sun to the moon
  - Can be penumbral, partial, or total eclipses
- Next total solar eclipse on April 8th
  - Just happens to be in the US!

Project Goals

- Investigate the relationships between Geographic Location/Solar Eclipse Frequency and Geographic Location/Path Width (Ashwin)
- Analyze different types of eclipses and examine whether they occur with greater frequency during specific months (Parvati)
- Analyze time differences between solar and lunar eclipses with respect to years and eclipse type (Jacob)
- Determine the ideal location for viewing solar eclipses, in terms of visibility and eclipse frequency (Bruno)

Analysis of Location and Solar Eclipse Frequency





Solar Eclipse Counts per 15x15 degree sector: Chi^2 statistic=242.7, p-value=0.668, dof=253

9	4	4	5	7	6	4	5	9	7	6	6	7	5	5	5	1	8	8	6	9	8	3	8
113	104	123	110	102	95	87	105	122	98	122	110	104	94	85	111	109	116	108	114	95	107	81	110
31	18	17	24	20	28	26	24	35	15	15	31	29	25	18	24	27	28	17	27	24	21	29	30
30	32	32	37	36	32	33	26	34	35	28	37	36	37	28	36	40	28	33	36	33	34	28	26
19	36	50	43	30	33	42	37	34	45	41	40	38	32	43	38	31	29	43	34	41	35	47	49
38	44	42	37	44	40	45	42	34	38	38	40	42	42	34	45	37	47	42	48	43	37	53	38
38	39	42	47	37	32	48	39	34	48	39	46	49	27	42	39	40	42	50	37	30	36	47	44
41	28	39	34	36	41	39	46	35	42	35	36	32	49	42	46	34	39	33	30	49	32	37	36
30	35	30	33	36	39	37	38	31	35	24	39	22	44	41	26	42	32	32	23	34	38	36	40
25	33	28	25	20	20	23	21	27	21	33	21	19	26	18	17	32	26	24	30	30	15	29	28
110	105	109	102	113	100	104	107	106	99	115	109	94	113	112	96	112	106	108	107	110	98	102	100
7	8	4	3	4	6	4	5	4	7	4	6	7	5	3	5	6	1	12	3	12	6	4	4

1-way ANOVA test across each latitude:
statistic=706.7665019914394
p-value=5.294355553665398e-195

Takeaways:

- Solar eclipse frequency **<u>does not</u>** depend on longitude
- Solar eclipse frequency **<u>does</u>** depend on latitude

Analysis of US Location and Solar Eclipse Type

	Northwest	Northeast	Southwest	Southeast
Partial	0	0	0	0
Annular	21	25	26	30
Total	27	21	24	26
Hybrid	3	2	1	4

Chi-Square Test: statistic=2.9, p-value=0.820, dof=6

Analysis of Hemisphere and Mean Path Width

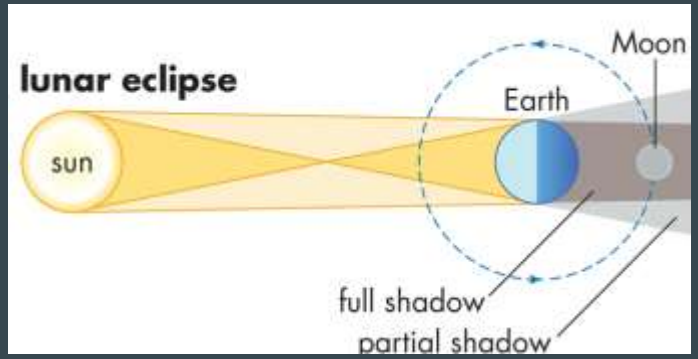
2 sample t-test for means between northern and southern path width:
statistic=-1.485
p-value=0.138
df=7512.36

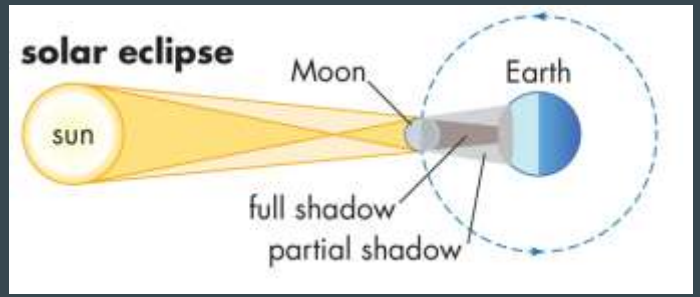
2 sample t-test for means between eastern and western path width:
statistic=-0.952
p-value=0.341
df=7494.69

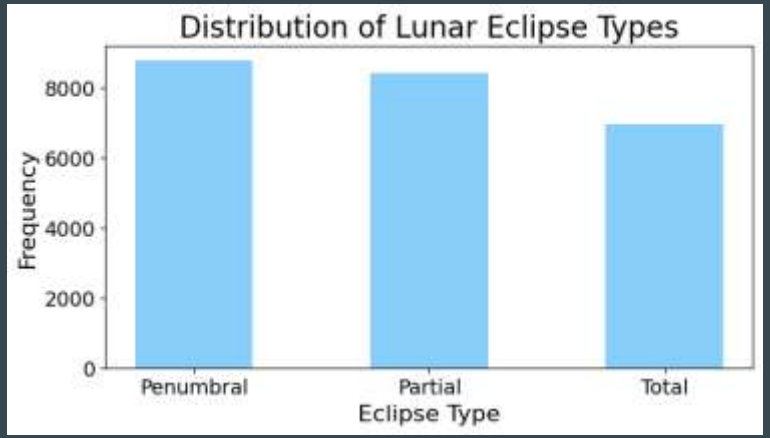
Takeaways:

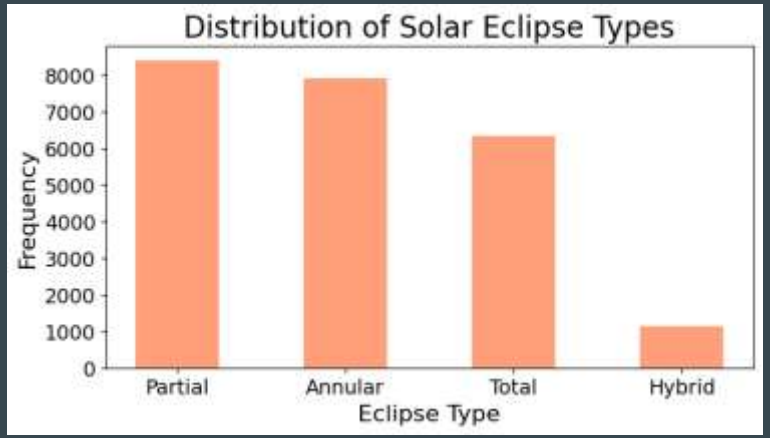
- Frequency of solar eclipse types **does not** depend on geographic location in the US
- Partial and Hybrid solar eclipses are incredibly rare in the US
- Annular and Total solar eclipses are similar in frequency in the US
- Mean path width **likely does not** depend on geographic location

Types of Lunar and Solar Eclipses

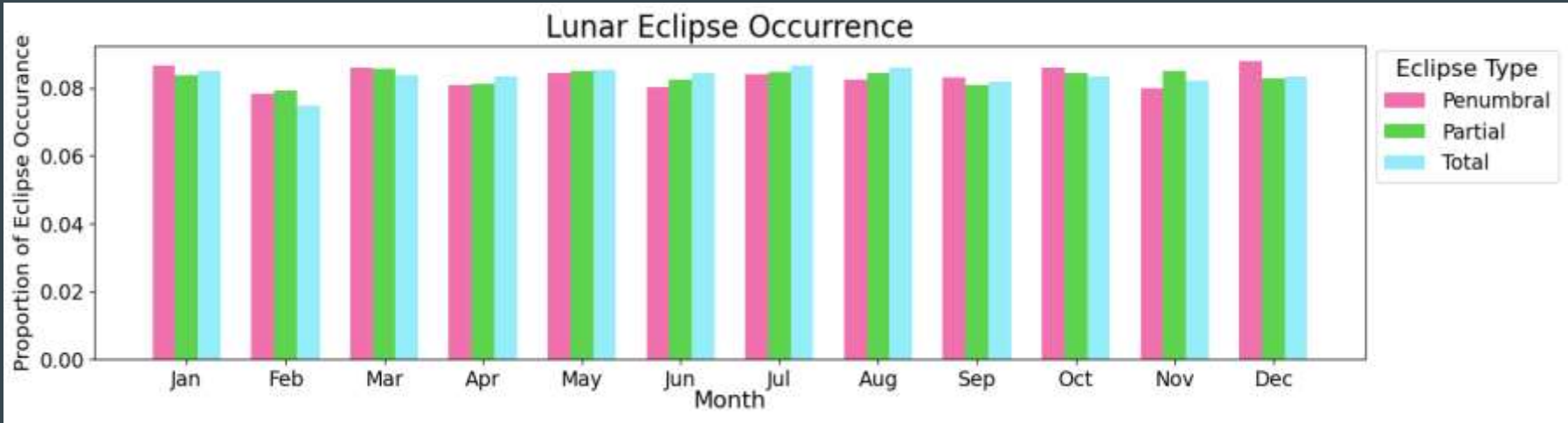








Lunar Eclipse Occurance



Penumbral eclipses occurring in May

95% CI: (0.07627 , 0.09275)

Partial eclipses occurring in May

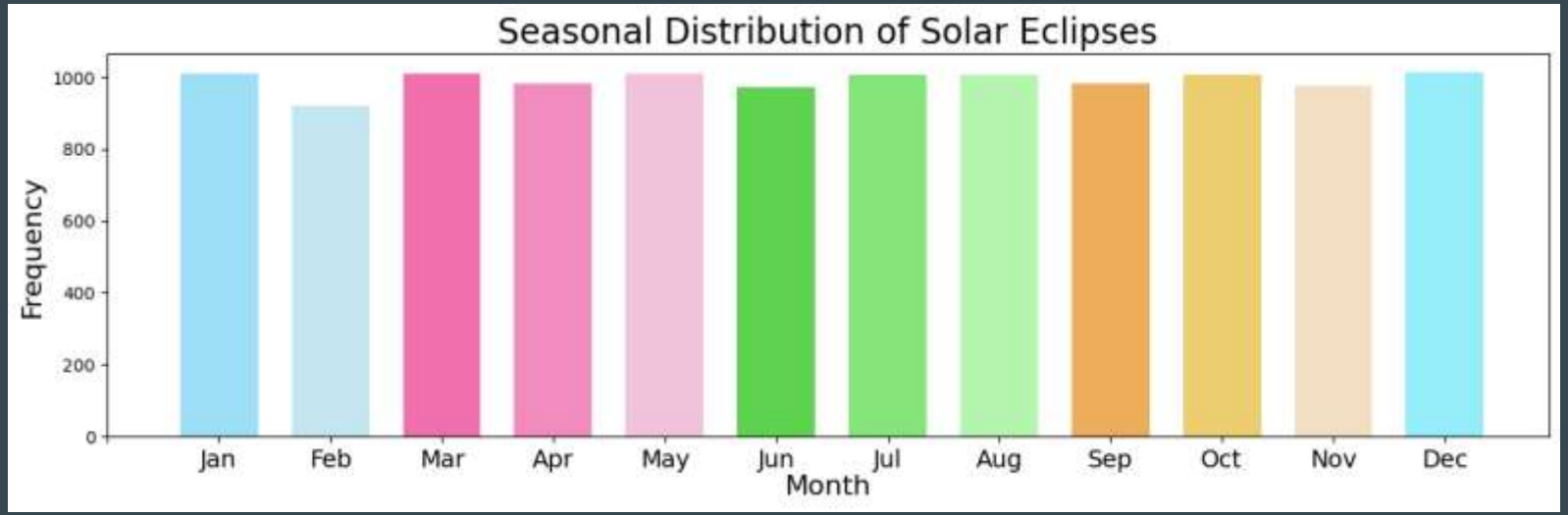
95% CI: (0.07666 , 0.09352)

Total eclipses occurring in May

95% CI: (0.07608 , 0.09465)

Chi-square test of independence: statistic = 8.97, df = 2, p-value = 0.011

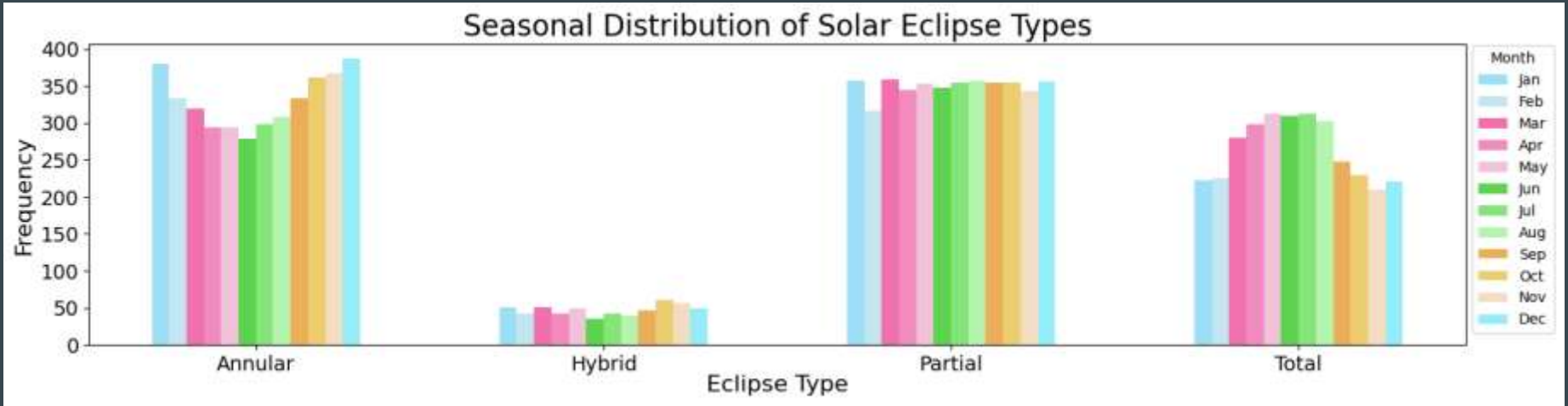
Seasonal Distribution of Solar Eclipses



Chi-Squared Test for Solar Eclipse Frequency Across Months:

- statistic (chi-square) = 8.358
- df = 11
- p-value = 0.6809

Seasonal Distribution of Solar Eclipse Types



Annular

statistic = 45.27
df = 11
p-value = 4.34e-06

Hybrid

statistic = 11.66
df = 11
p-value = 0.39

Partial

statistic = 4.14
df = 11
p-value = 0.96

Total

statistic = 72.93
df = 11
p-value = 3.38e-11

Time Difference between Solar and Lunar Eclipses

Two sample t-test for means:

Group 1 yrs. 1 A.D. - 2023, Group 2 yrs. 2024-3000:

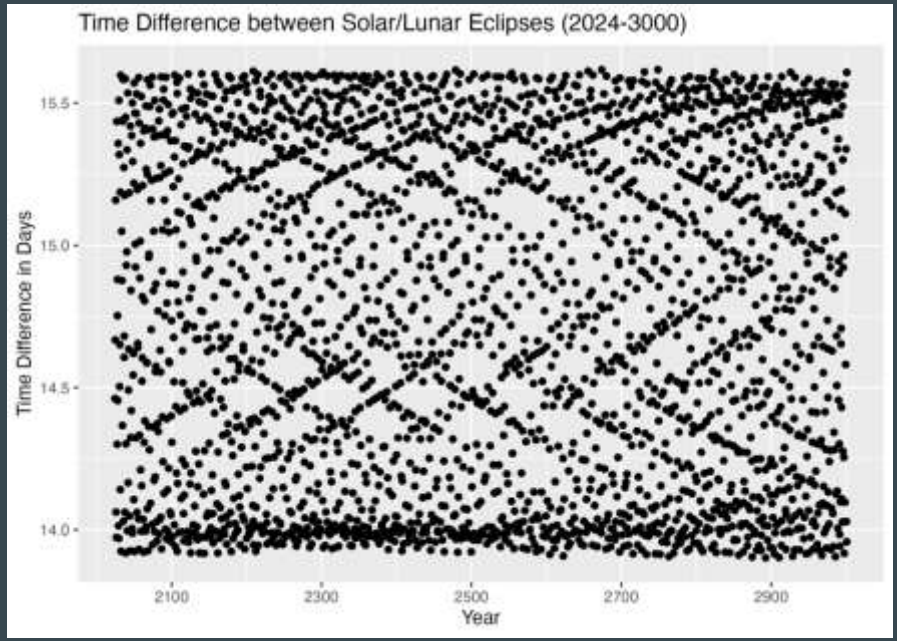
p-value = 0.874

df = 8046

95% confidence interval: (-0.0246, 0.0289)

Takeaways:

- No significant difference in group means
- High periodicity based on time series analysis
- Low variability with maxima around 15.75 days and minima around 13.75 days



Time Difference by Eclipse Type

ANOVA test for time differences by eclipse type:

p-value = 0.00538
df = 4
F-stat = 3.677

Linear Regression for time differences by eclipse type:

Reference Category: Annular Eclipse (occur yearly)
Partial: p-value = 0.000952
Total: p-value = 0.001351

95% CI for Total Eclipse Time Difference: (0.0234, 0.0971)

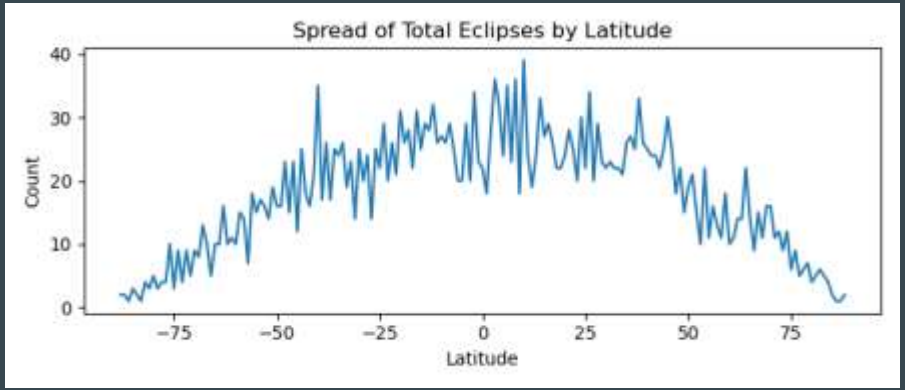
Takeaways:

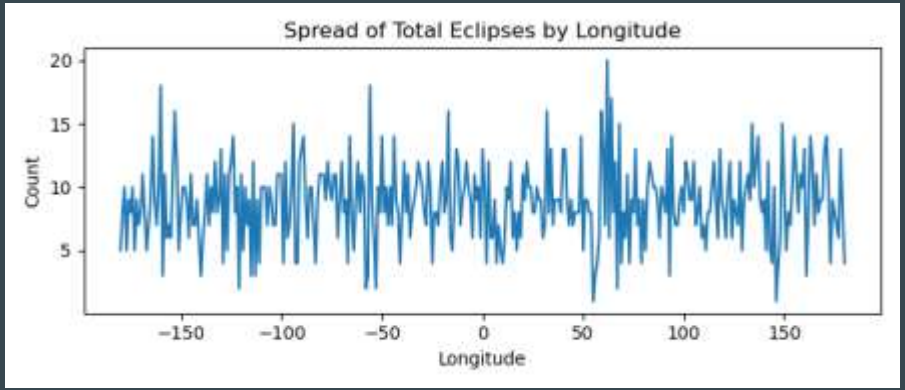
- Significant difference in eclipse type mean time difference
- Partial and Total eclipses see time differences longer than a difference that includes an annular eclipse
- Total eclipses on average 0.56-2.33 hour longer time difference between eclipses

Ideal Viewing Locations For Total Eclipses

- A combination of:
  - High eclipse frequency
  - High visibility
    - Low cloud cover

- Higher frequency near 0 latitude
- No significant difference across longitude
- When factoring in visibility...

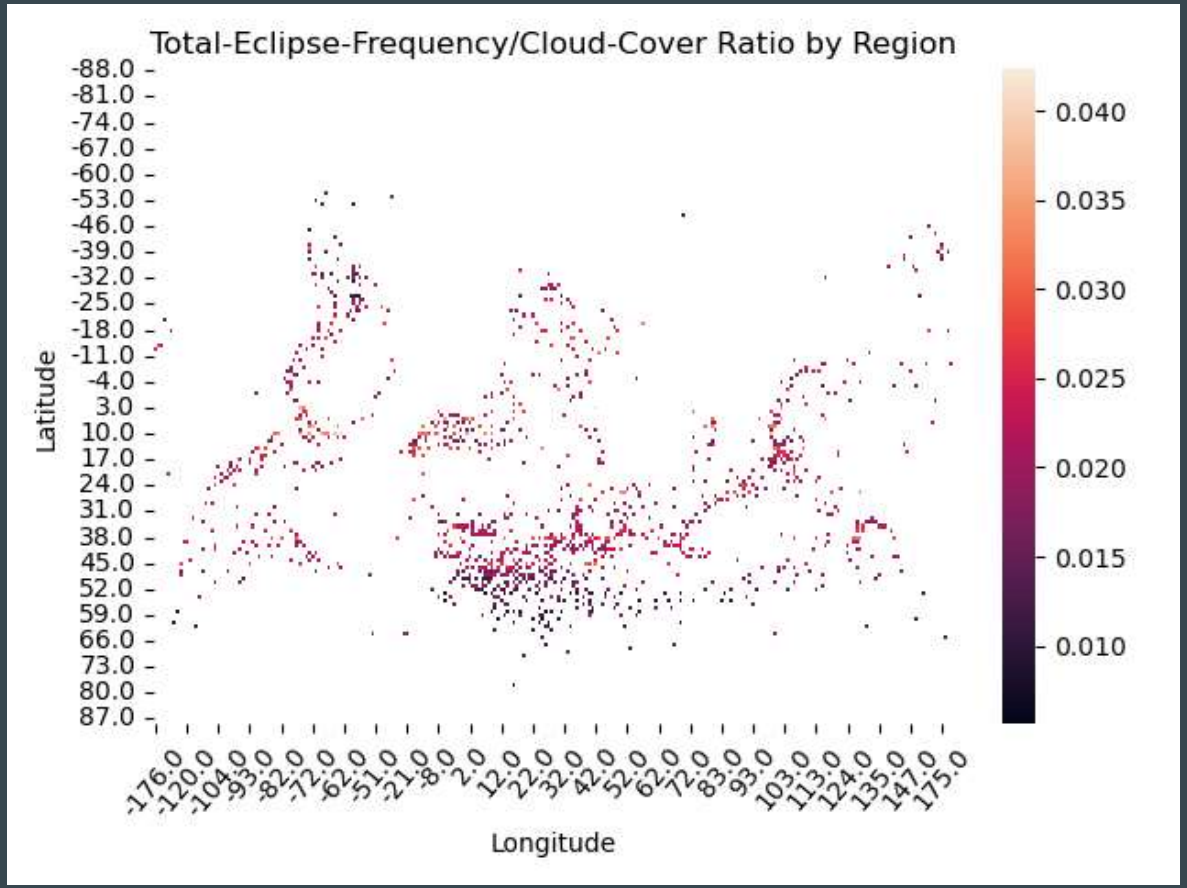




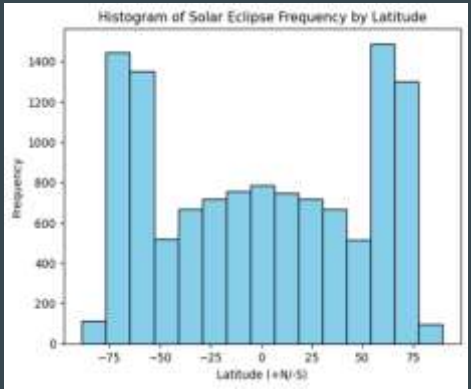
Ideal Viewing Locations

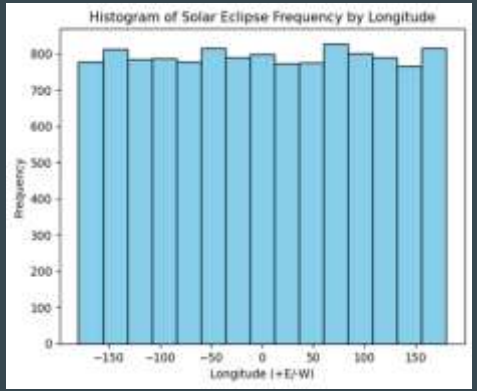
The locations with the best chances of seeing an eclipse are:

- 42.0 3.0
- -63.0 10.0
- -65.0 10.0
- 99.0 10.0
- -76.0 10.0



Questions?


Histogram of Solar Eclipse Frequency by Latitude
Frequency
0
200
400
600
800
1000
1200
1400
−75
−50
−25
0
25
50
75
Latitude (+N/-S)


Histogram of Solar Eclipse Frequency by Longitude
Frequency
0
100
200
300
400
500
600
700
800
−150
−100
−50
0
50
100
150
Longitude (+E/-W)