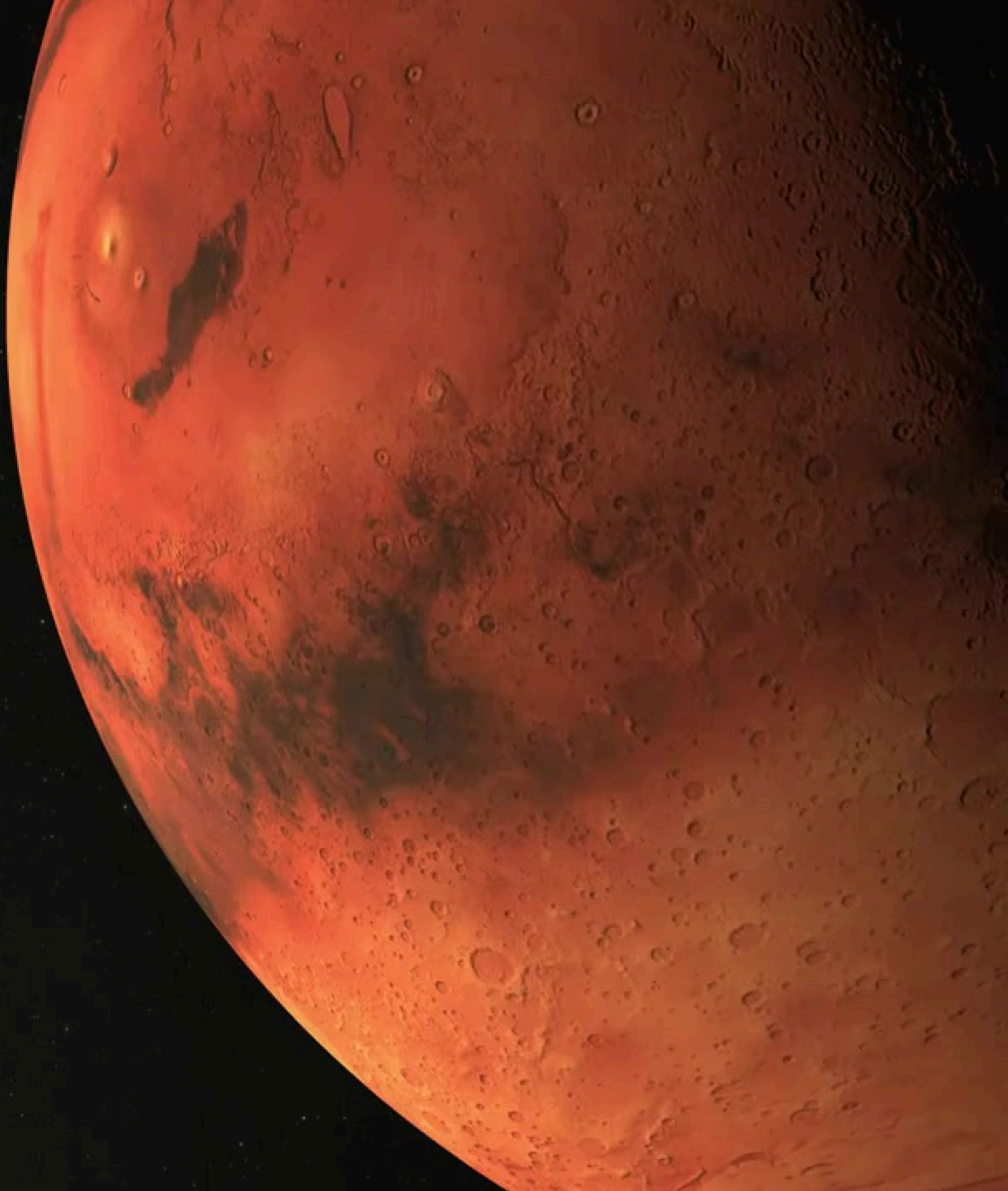
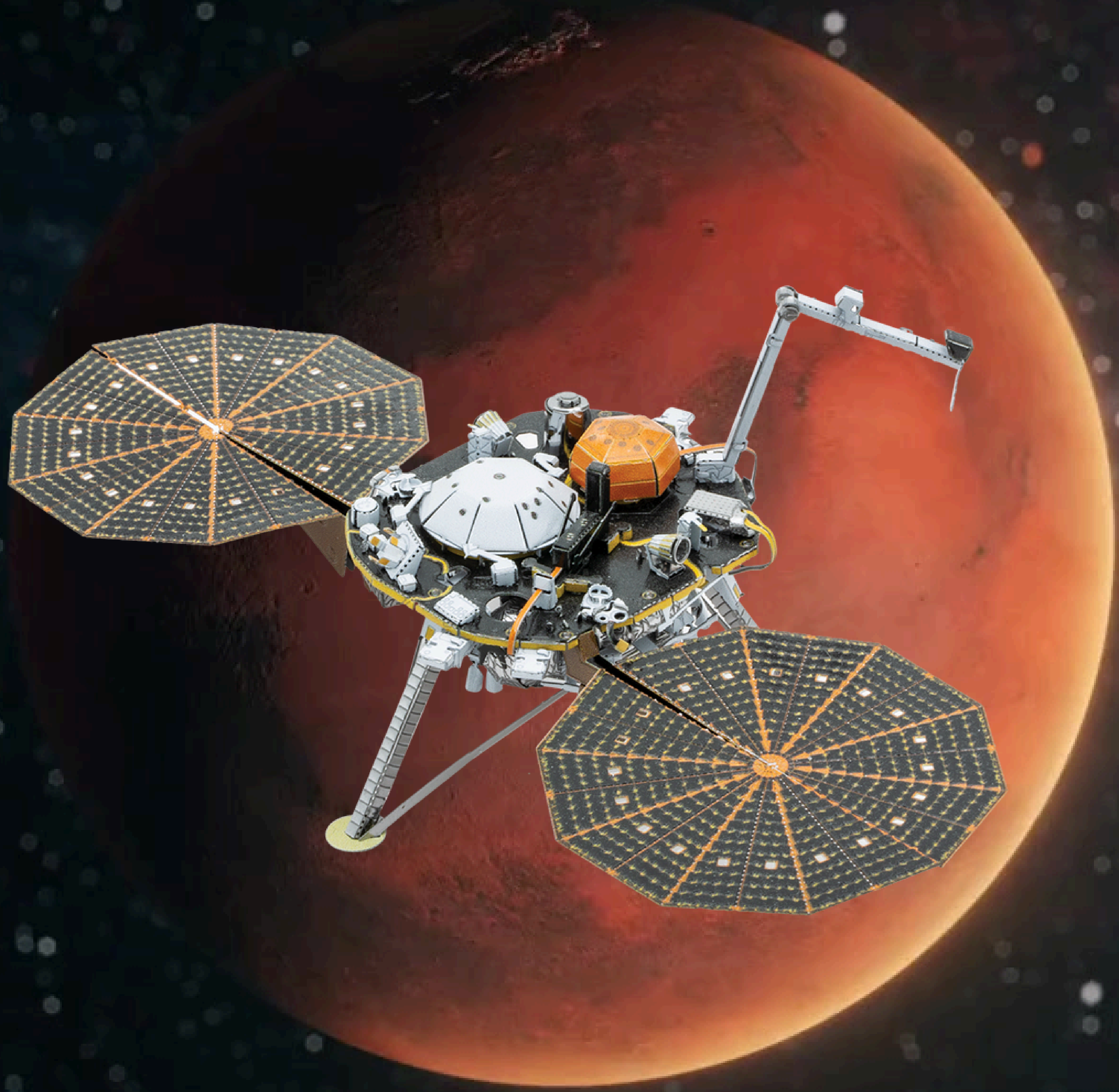
PYTHON FOR DATA SCIENCE AND AI

INSIGHT: MARS

23229514 Annisa Danish Kamila

23229538 Enkhbat Bolortuya





WHAT IS INSIGHT?

InSight is a robotic lander on Mars.

Its job is to study the inside of the planet, but it also has tools to measure the weather on the surface.

WHAT IS A "SOL"?

- A "Sol" is simply what scientists call a day on Mars.
- A Martian day is a little bit longer than an Earth day (about 24 hours and 39 minutes).
- The weather data we used in this project covers a few Martian days, from Sol 675 to Sol 681.

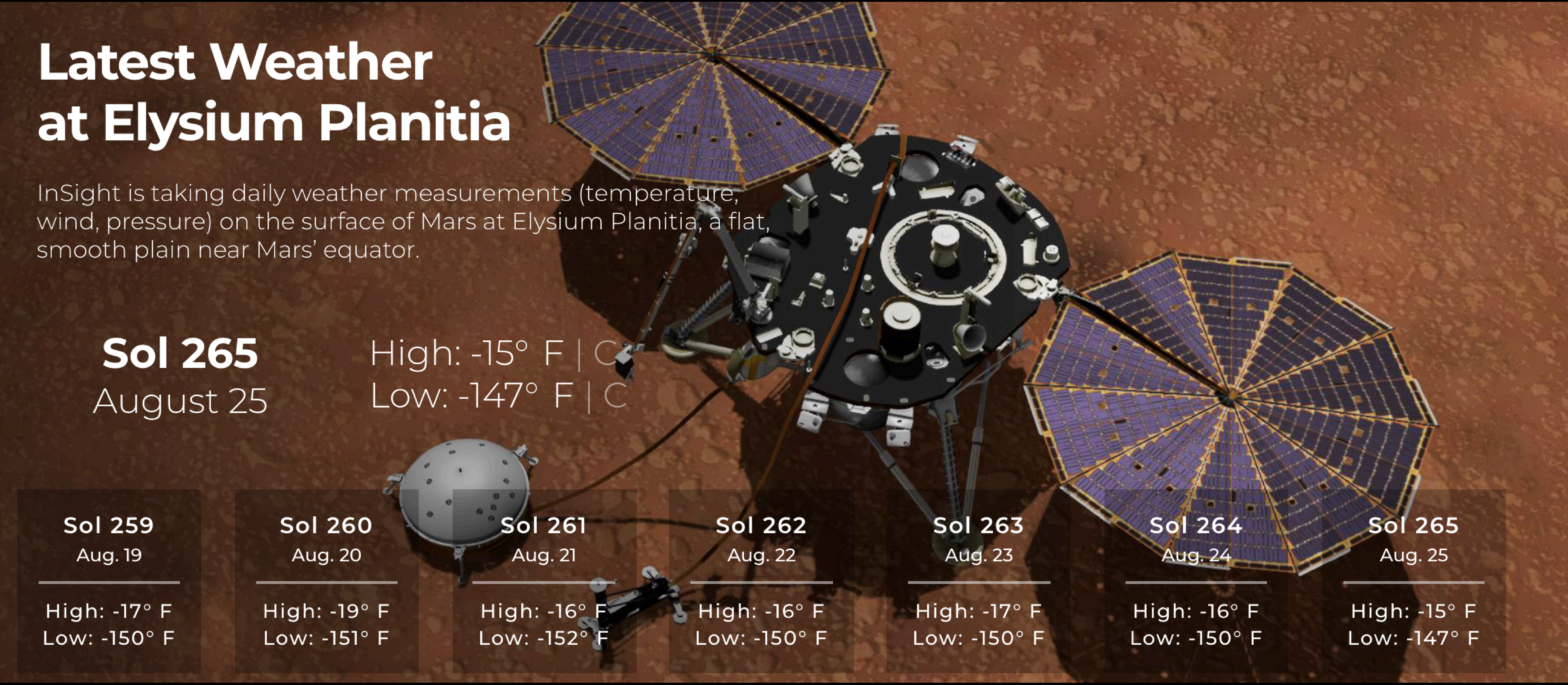


Image retrieved from https://api.nasa.gov/

DATA COLLECTION

We got data for several Martian days (Sols).

For each Sol, we have information like:

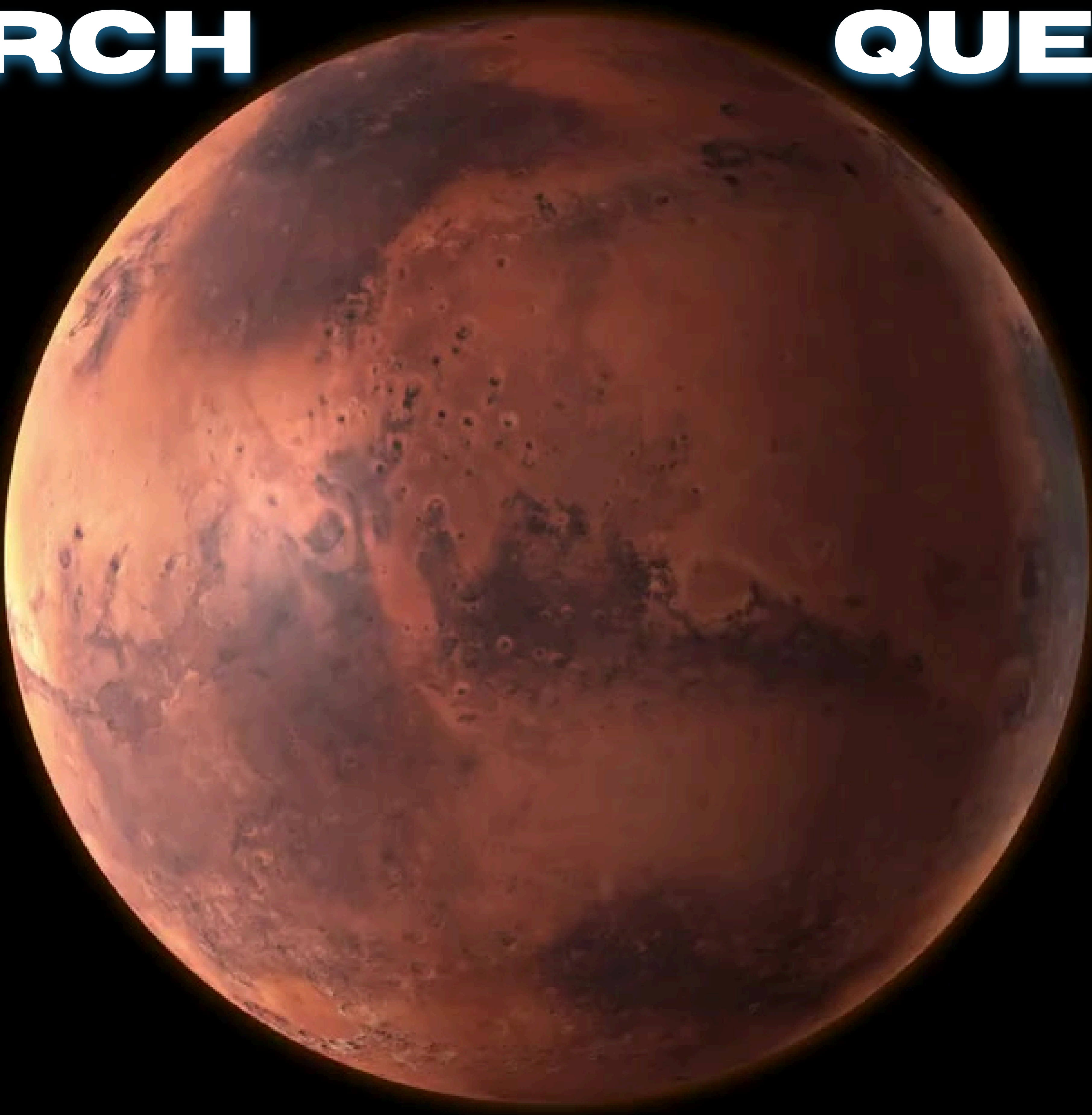
- The Martian day number (Sol)
- The Earth date and time the data was recorded
- The average air pressure for that Sol
- The average wind speed for that Sol

Processed Mars Weather Data:

	sol	earth_date	average_pressure	average_wind_speed
0	675	2020-10-19 18:32:20+00:00	750.563	7.233
1	676	2020-10-20 19:11:55+00:00	749.090	8.526
2	677	2020-10-21 19:51:31+00:00	748.698	7.887
3	678	2020-10-22 20:31:06+00:00	743.741	5.246
4	679	2020-10-23 21:10:41+00:00	744.529	5.565

```
DataFrame Info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7 entries, 0 to 6
Data columns (total 4 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   sol                 7 non-null      int64
 1   earth_date          7 non-null      datetime64[ns, UTC]
 2   average_pressure    7 non-null      float64
 3   average_wind_speed  7 non-null      float64
dtypes: datetime64[ns, UTC](1), float64(2), int64(1)
memory usage: 356.0 bytes
None
```

RESEARCH QUESTIONS



Is there a relationship between the average pressure and the average wind speed on Mars? Specifically, is there a tendency for lower average pressure to be associated with higher average wind speeds?

How much does the weather jump around (how stable is it) over just two Martian days compared to over five Martian days? Do both air pressure and wind speed determine if their stability differs over these time periods?

QUESTION ONE

Research Question: Is there a connection between how high or low the air pressure is and how fast the wind blows on Mars? Do lower pressures usually mean faster winds?

Null Hypothesis (H_0): There is **no** clear connection between the average air pressure and the average wind speed on Mars. They don't consistently go up or down together.

Alternative Hypothesis (H_1): There **is** a connection: when the average air pressure goes down, the average wind speed tends to go up.

METHODOLOGY

We analyzed several sols, separating them into two groups — one with below-median pressure and one with above-median pressure.

- The test result showed a statistically significant difference.
  - The test statistic was approximately -2.035.
  - The p-value was approximately 1.022e-01.

Since the p-value (0.1022) is greater than the 0.05 significance level, we fail to reject the null hypothesis. This indicates that there is no statistically significant difference in average wind speed between low-pressure and high-pressure Sols.

```python
sol_keys = mars_data["sol_keys"]
records = []

for sol in sol_keys:
    info = mars_data[sol]
    records.append({
        "Sol": int(sol),
        "Average_Pressure": info.get("PRE", {}).get("av"),
        "Average_Wind_Speed": info.get("HWS", {}).get("av"),
    })

data = pd.DataFrame(records).dropna()
```

```python
# Split into low and high pressure groups
median_pressure = data["Average_Pressure"].median()
low_pressure = data[data["Average_Pressure"] < median_pressure]["Average_Wind_Speed"]
high_pressure = data[data["Average_Pressure"] >= median_pressure]["Average_Wind_Speed"]
```

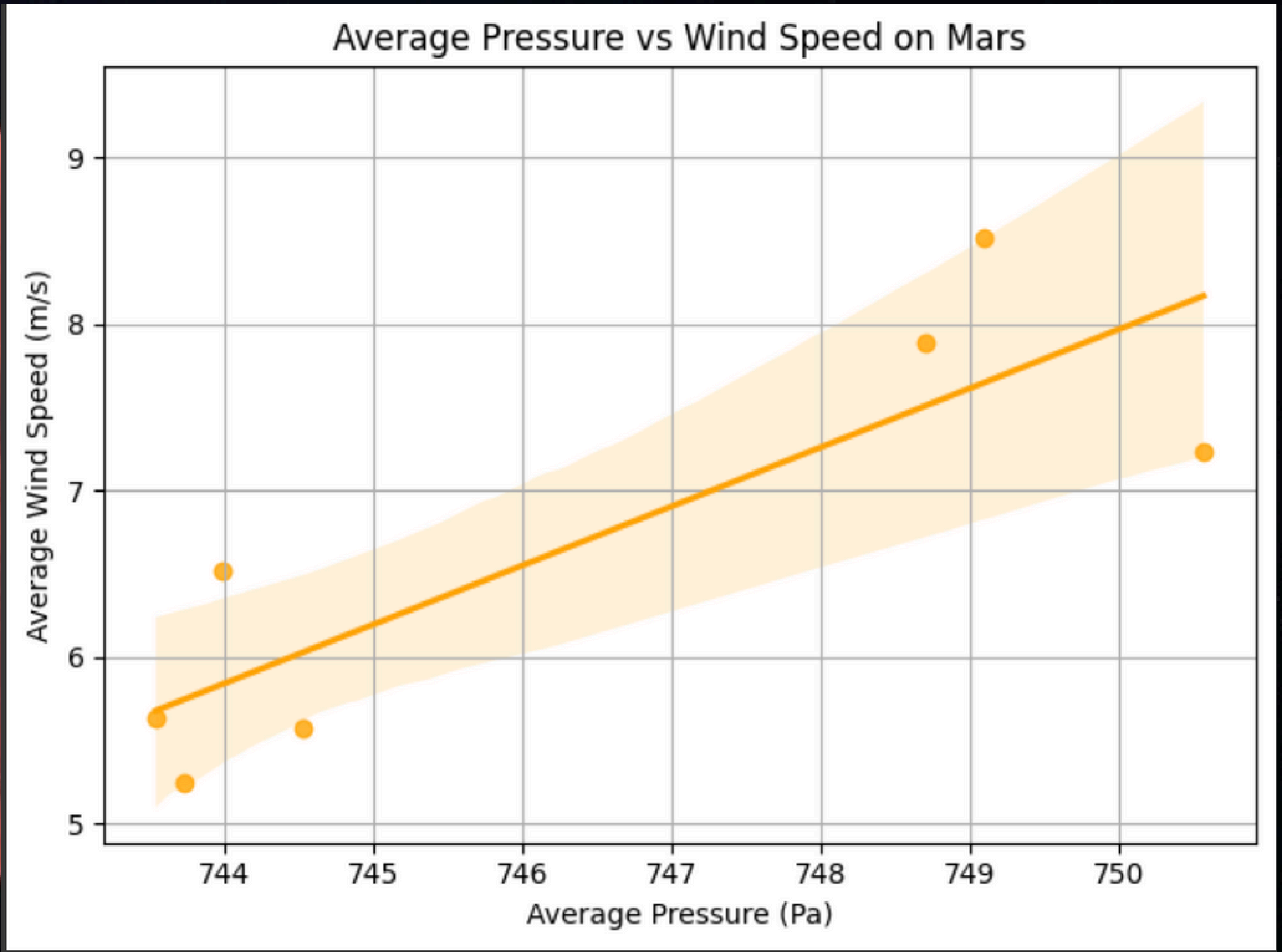
```python
# Independent t-test
from scipy import stats
t_stat, p_value = stats.ttest_ind(low_pressure, high_pressure, equal_var=False)
print(f"T-statistic: {t_stat:.3f}, P-value: {p_value:.3e}")
```

```
T-statistic: -2.035, P-value: 1.022e-01
```

```python
# Interpretation
if p_value < 0.05:
    print("Reject Null Hypothesis: Lower pressure corresponds to higher wind speeds.")
else:
    print("Fail to Reject Null Hypothesis: No significant relationship detected.")
```

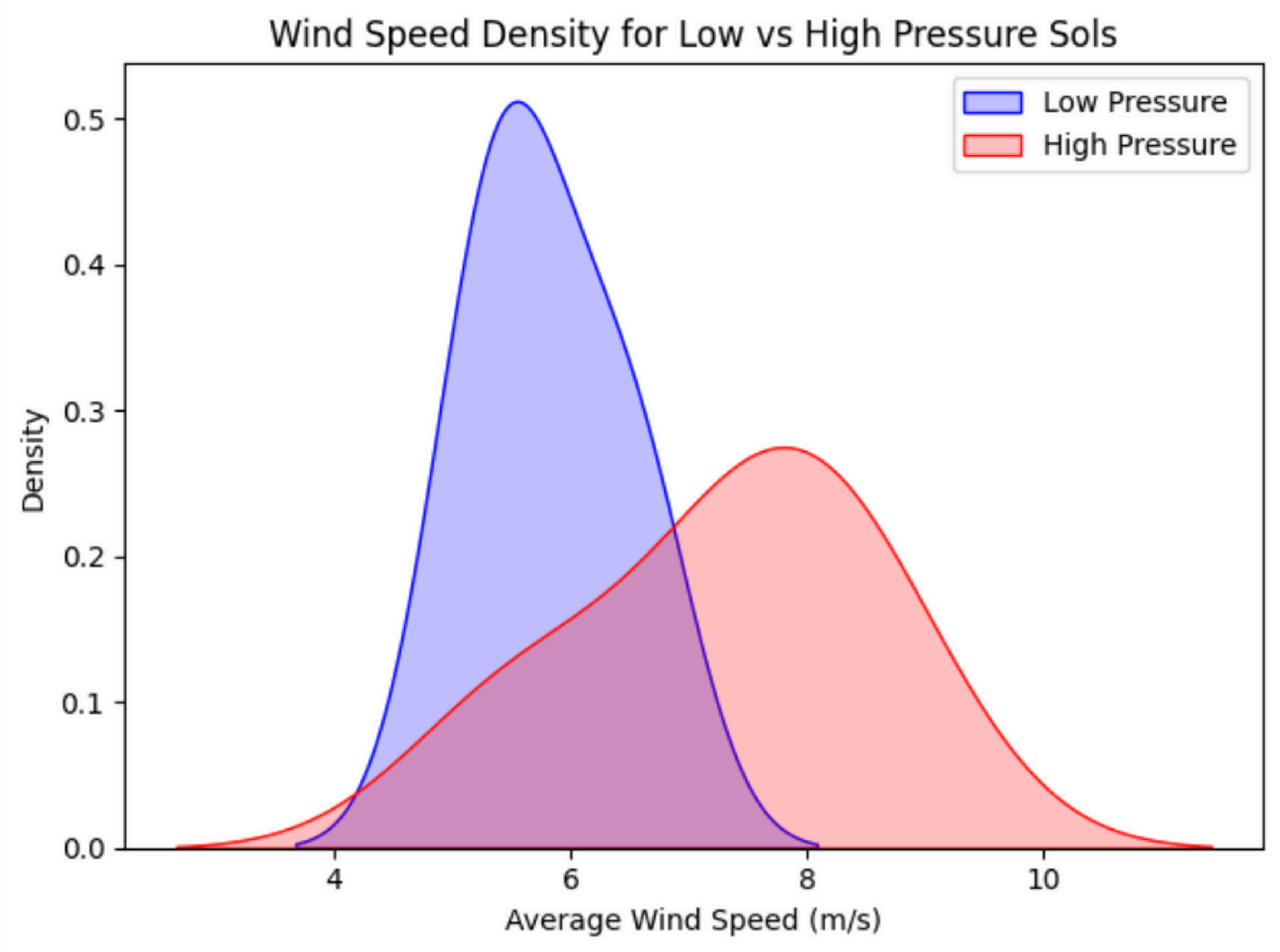
```
Fail to Reject Null Hypothesis: No significant relationship detected.
```

VISUALISATION 1: SCATTERPLOT



Based on this plot, you can see a slight negative correlation — as pressure decreases, wind speed seems to increase slightly, though the relationship doesn't appear very strong.

VISUALISATION 2: DISTRIBUTION OVERLAY



- You can see that high-pressure sols tend to have a broader range and higher average wind speeds, while low-pressure sols have a more concentrated, lower wind speed range.
- The overlap shows that both groups have similar ranges, but their average wind speeds follow different patterns.

WHAT DOES THIS ALL MEAN?

Combining the results from the statistical test and the two visualizations, the analysis suggests that, for this dataset, there is no significant relationship or difference in average wind speed based on atmospheric pressure levels on Mars. While the scatterplot hinted at a potential weak negative trend, the t-test and density plots indicate that any observed difference is not statistically significant and the distributions of wind speeds for low and high pressure are largely overlapping.

QUESTION TWO

Research Question: How much does the weather jumps around (how stable is it) over just two Martian days compared to over five Martian days?

Null Hypothesis (H_0): **The average** amount the weather jumps around **is the same** whether you look at it over 2 days or 5 days.

Alternative Hypothesis (H_1): **The average** amount the weather jumps around over 2 days **is different** than over 5 days.

MEASURING "JUMPINESS"

Stability for 2-Sol Windows (Average Pressure):

	Window Sols	Average Pressure Stability (Std Dev)
0	(675, 676)	1.041568
1	(676, 677)	0.277186
2	(677, 678)	3.505128
3	(678, 679)	0.557200
4	(679, 680)	0.381131
5	(680, 681)	0.311127

Stability for 5-Sol Windows (Average Pressure):

	Window Sols	Average Pressure Stability (Std Dev)
0	(675, 676, 677, 678, 679)	3.006146
1	(676, 677, 678, 679, 680)	2.652068
2	(677, 678, 679, 680, 681)	2.153852

Stability for 2-Sol Windows:

	Window Sols	Wind Speed Stability (Std Dev)
0	(675, 676)	0.914289
1	(676, 677)	0.451841
2	(677, 678)	1.867469
3	(678, 679)	0.225567
4	(679, 680)	0.673166
5	(680, 681)	0.625790

Stability for 5-Sol Windows:

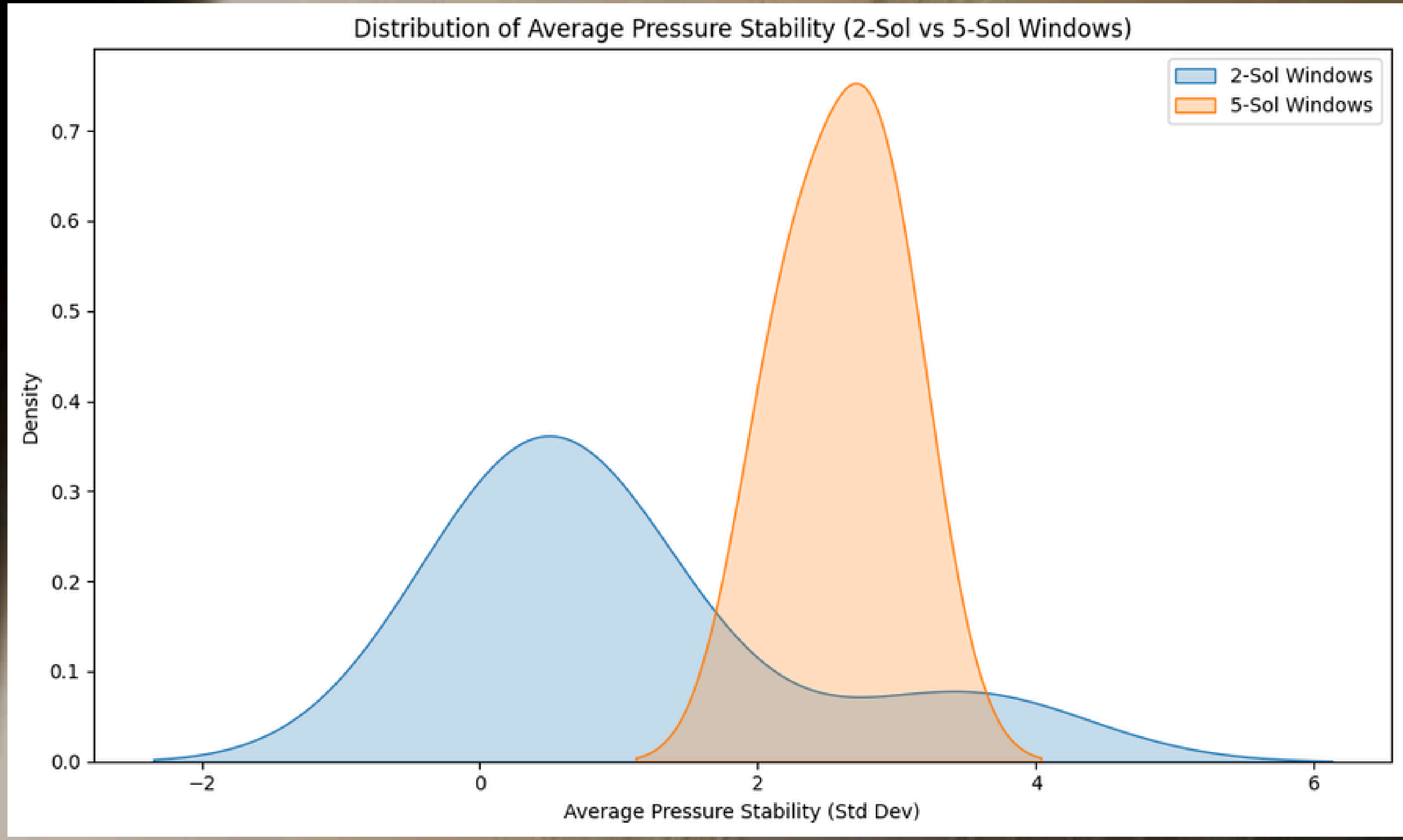
	Window Sols	Wind Speed Stability (Std Dev)
0	(675, 676, 677, 678, 679)	1.435836
1	(676, 677, 678, 679, 680)	1.428938
2	(677, 678, 679, 680, 681)	1.069783

AIR PRESSURE

We used an independent samples t-test because we were comparing the means of two independent groups of data.

- The test result showed a statistically significant difference.
  - The test statistic was approximately -2.80.
  - The p-value was approximately 0.0277.

Since the p-value (0.0277) is less than the significance level of 0.05, we reject the null hypothesis. There is sufficient evidence to conclude that the average for 2-sol windows is significantly different from the average for 5-sol windows.




```
from scipy import stats
import pandas as pd

two_sol_stability_pressure_series = df_two_sol_stability_pressure['Average Pressure Stability (Std Dev)']
five_sol_stability_pressure_series = df_five_sol_stability_pressure['Average Pressure Stability (Std Dev)']

ttest_result_pressure_stability = stats.ttest_ind(two_sol_stability_pressure_series, five_sol_stability_pressure_series, equal_var=False)

print("Independent Samples t-test results for Average Pressure Stability (2-sol vs 5-sol windows):")
print(f"Test Statistic: {ttest_result_pressure_stability.statistic}")
print(f"P-value: {ttest_result_pressure_stability.pvalue}")
```

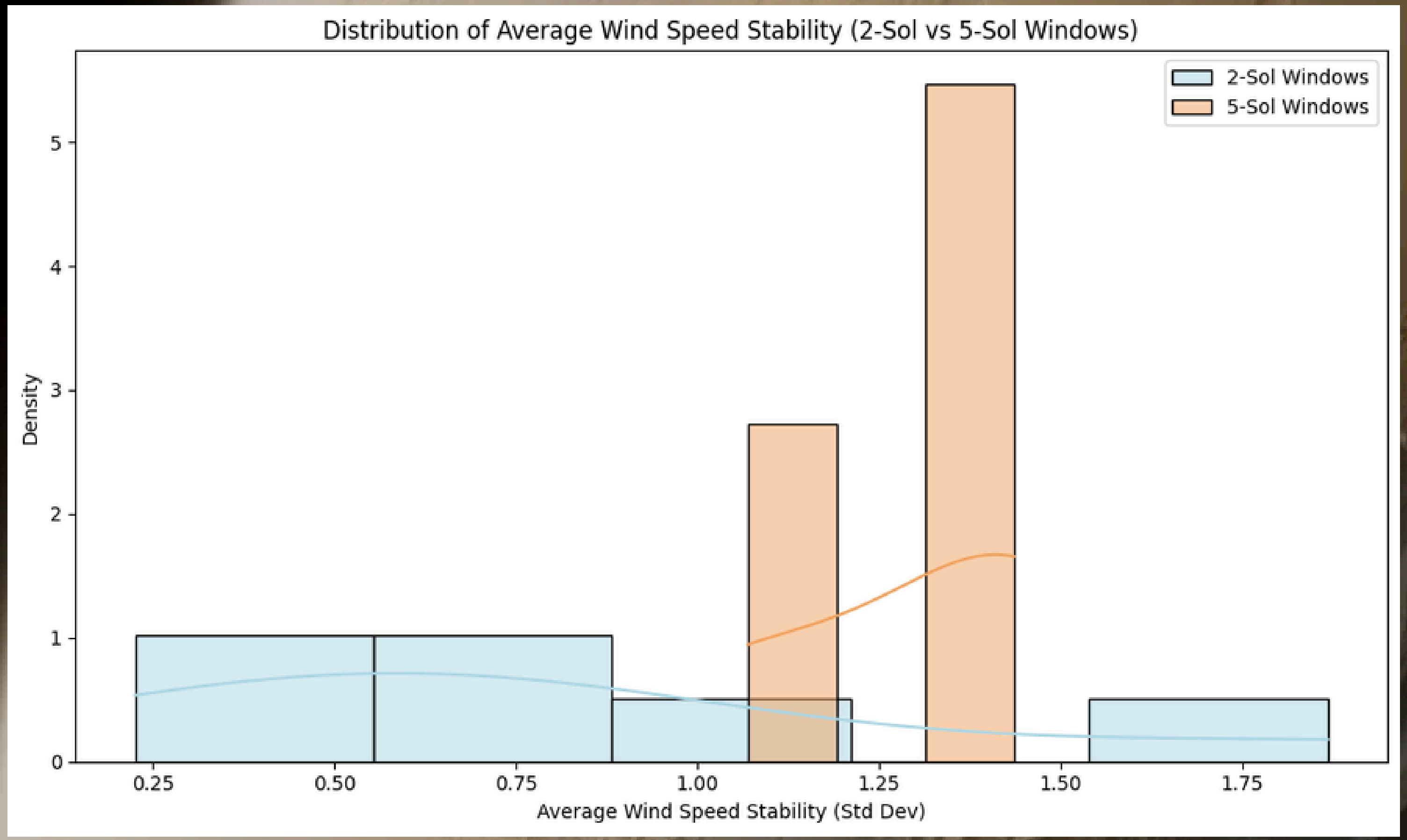
```
Independent Samples t-test results for Average Pressure Stability (2-sol vs 5-sol windows):
Test Statistic: -2.801423250275807
P-value: 0.027715439443485104
```

WIND SPEED

We did the same comparison for the average "jumpiness scores" for wind speed using an independent t-test as well.

- The test result did not show a statistically significant difference.
  - The test statistic was approximately -1.97.
  - The p-value was approximately 0.0913.

Since the p-value (0.0913) is greater than the common significance level of 0.05, we fail to reject the null hypothesis. There is not enough evidence that the average for 2-sol windows is significantly different from the average for 5-sol windows.

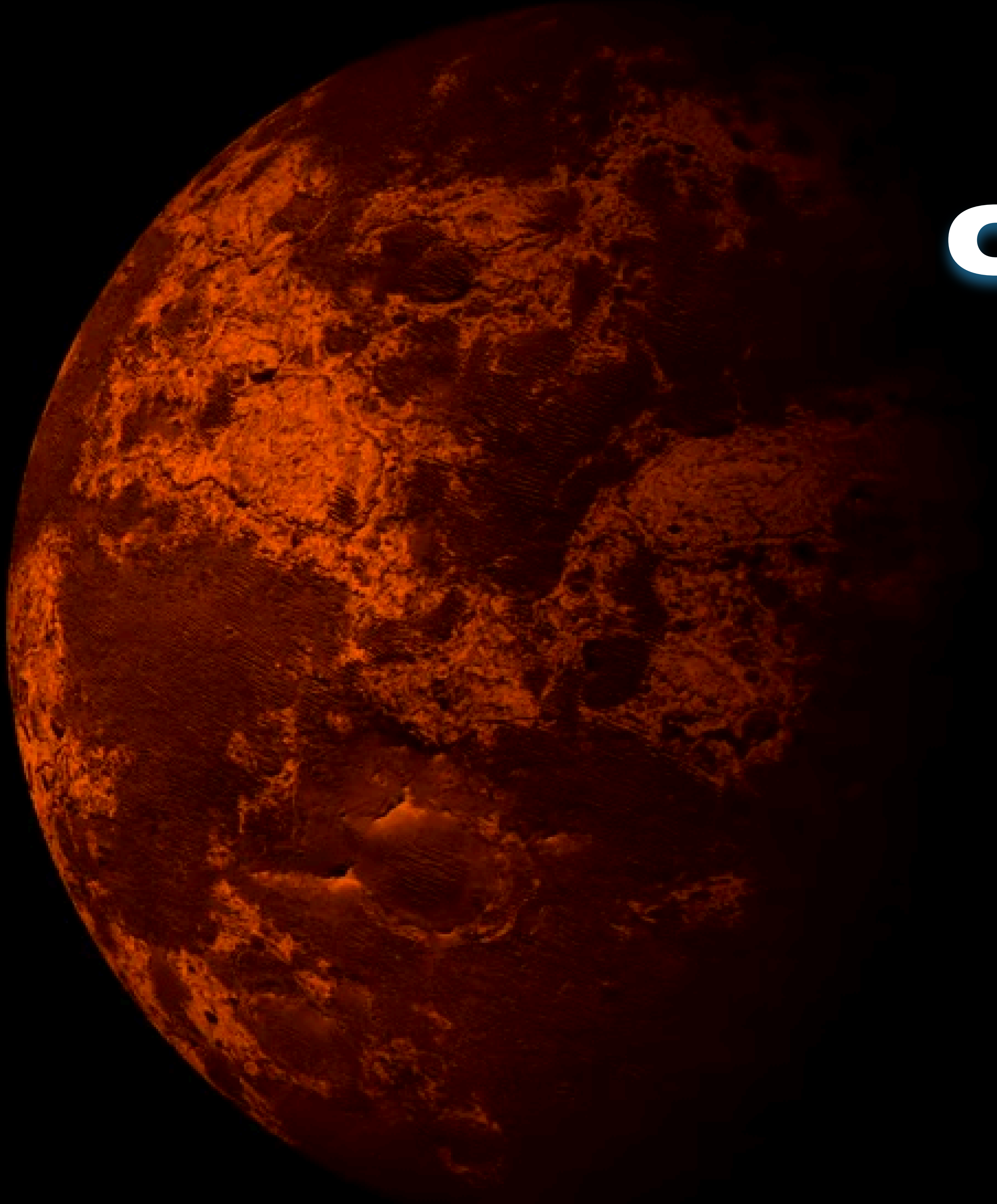



```
from scipy import stats
import pandas as pd

two_sol_stability_wind_series = df_two_sol_stability['Wind Speed Stability (Std Dev)']
five_sol_stability_wind_series = df_five_sol_stability['Wind Speed Stability (Std Dev)']

ttest_result_wind_stability = stats.ttest_ind(two_sol_stability_wind_series, five_sol_stability_wind_series, equal_var=False)

print("Independent Samples t-test results for Average Wind Speed Stability (2-sol vs 5-sol windows):")
print(f"Test Statistic: {ttest_result_wind_stability.statistic}")
print(f"P-value: {ttest_result_wind_stability.pvalue}")
```

```
Independent Samples t-test results for Average Wind Speed Stability (2-sol vs 5-sol windows):
Test Statistic: -1.965235164792803
P-value: 0.0912819959446995
```

WHAT DOES THIS ALL MEAN?

- Based on our analysis of this short period of Mars weather data:
    - The stability of air pressure appears to be different when looking at 2-day periods versus 5-day periods.
    - The stability of wind speed, however, did not show a significant difference between these two time periods with our data.
- This suggests that different aspects of the weather on Mars might behave uniquely in terms of how much they vary over short versus slightly longer time scales.



CONCLUSION

Martian weather might behave uniquely compared to Earth, but it's important to remember our analysis used very limited data based on what the public API gave us. Future studies with more extensive data are needed to confirm these observations and build a more complete picture of Mars's atmosphere.

REFERENCES

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