NASA High Altitude Balloon Mission 2024

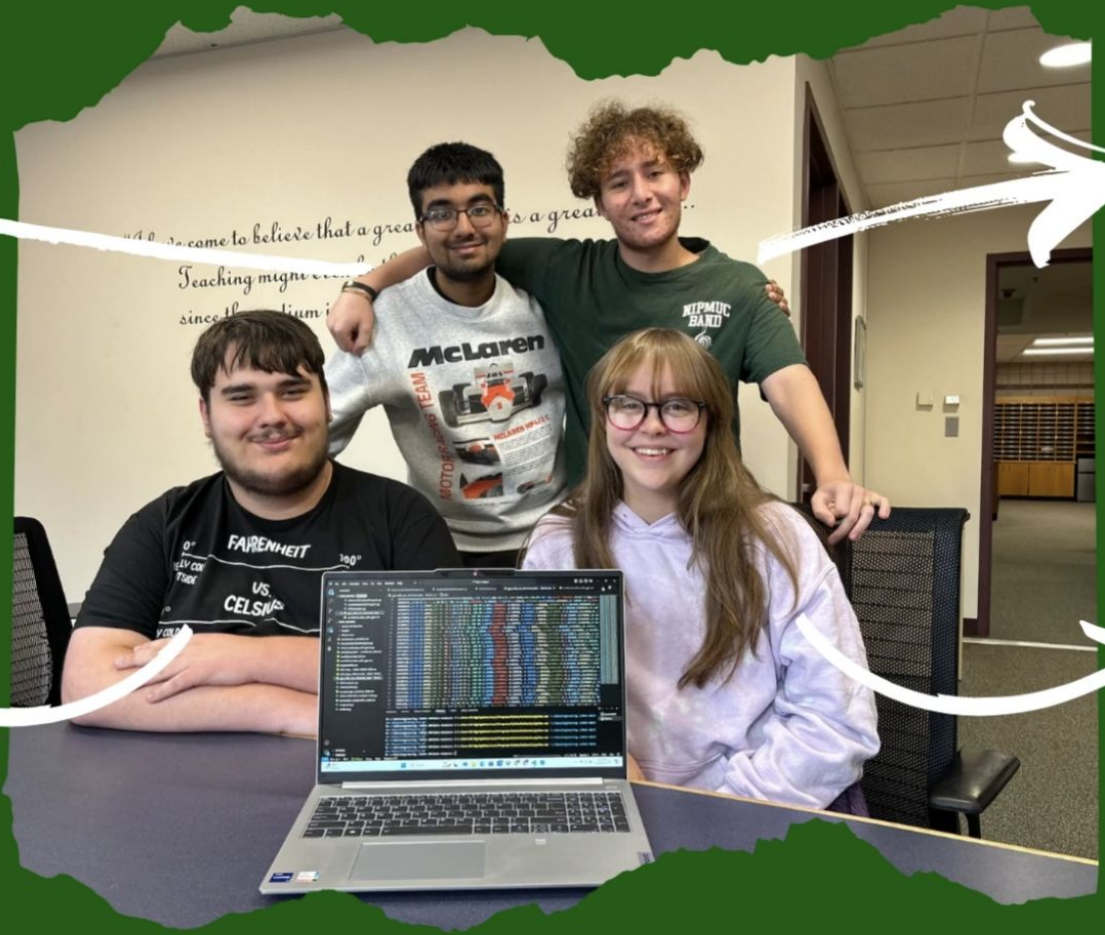
Nipmuc Regional High School

Jorvan

Documentation, photography, circuitry

Meko

Programming, CAD, and 3D printing



Mark

Scientific analysis and conclusions; chief researcher

Bridget

Coding and data analysis expert

The NASA HAB Mission

MAXIQ.Space project to collect data on a High Altitude Balloon.

The 2024 NASA HAB Mission launched from Fort Sumner, New Mexico in August.

MAXIQ

Science & Engineering Goals

01 Attaching the Sparkfun Chip

Learning how to use the MaxIQ prototype chip with Sparkfun I2C connection.

02 Atmospheric Monitoring

Collect large amounts of concentrations in the atmosphere to answer questions like: What does the atmosphere look like now? Is is expected?

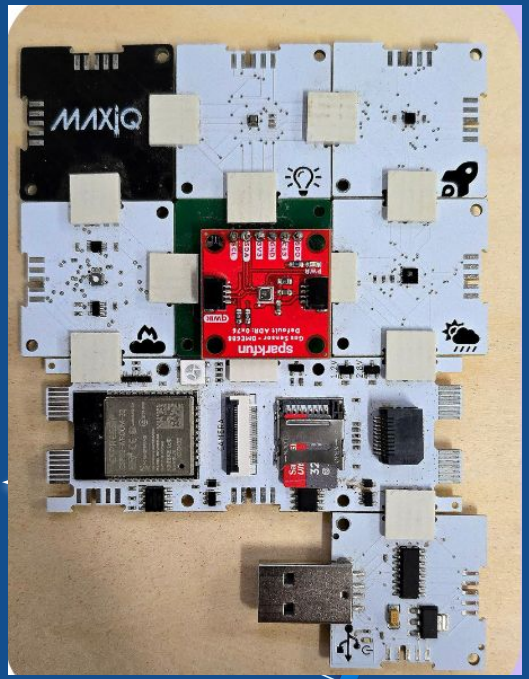
03 Resiliency in Data Recording

Be able to withstand multiple starts and stops in data recording in chunks to reduce data corruption.

04 Modeling Climate Change

Be able to use collected data to observe trends in climate models and make predictions.

Payload Layout



SPC30: Air Quality sensor

KXTJ3: Accelerometer

LTR-390: Measures ambient/UV Light

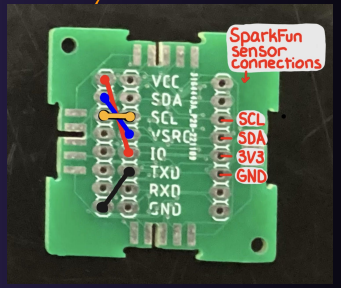
AHT21: Temperature & humidity sensor

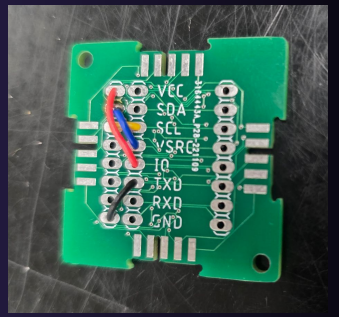
Sparkfun BME688: Gas scanning sensor

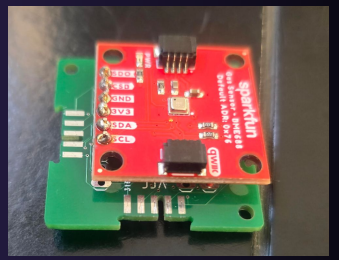
Extended Core: CPU core

PPU-USB: for power & programming

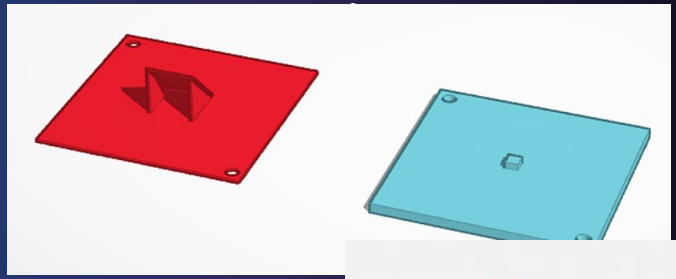
Spacer: blank chip

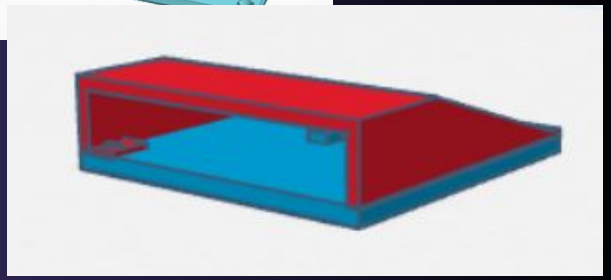




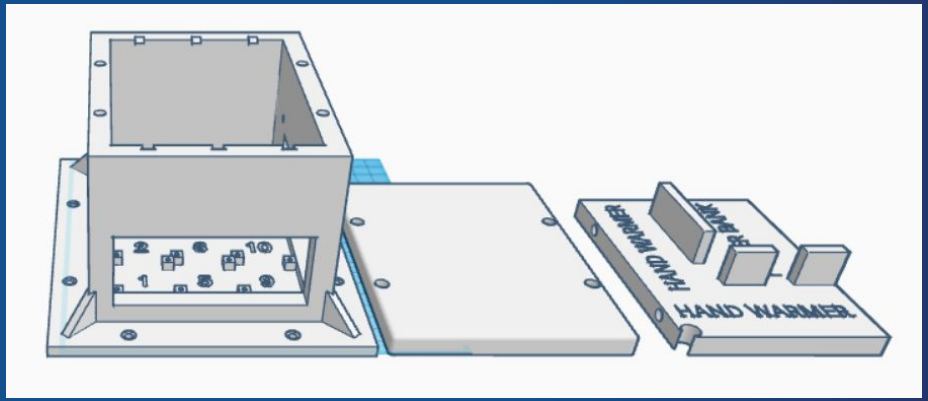


Payload Housing And Internal





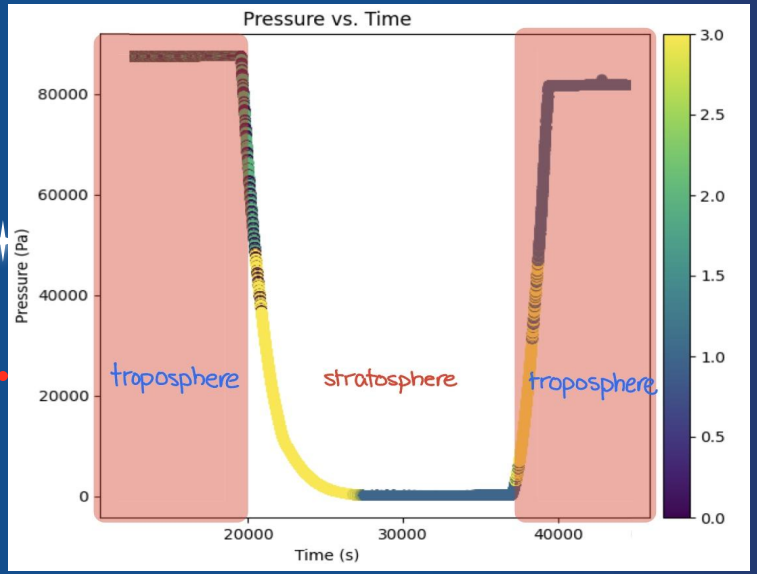
We originally planned to include an add-on to the light sensor, to direct as much light as possible to the sensor, but cam along many problems that we were not able to solve in time for the launch.

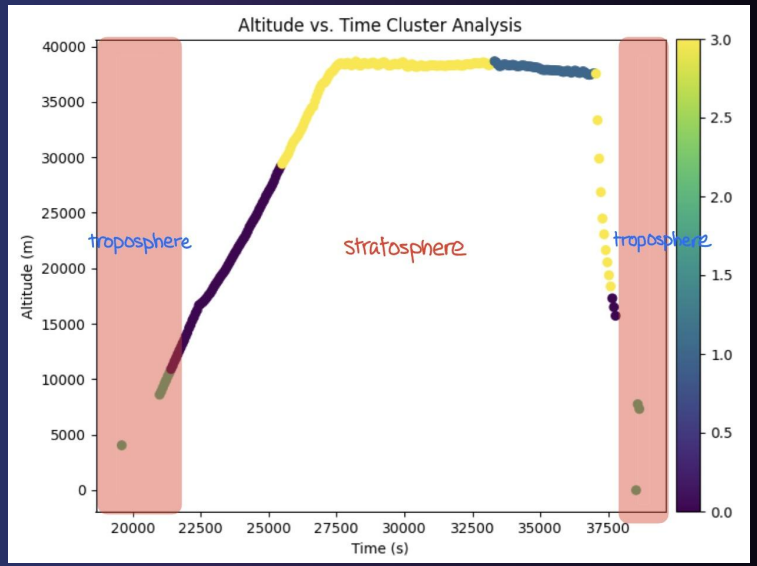


For the main payload housing, we had to include enough room for 4 different circuit boards. We screwed them in both to the housing and to each other. On the top of the payload, we had another level to include a battery pack to power all the boards and multiple hand warmers to keep them running in the cold atmosphere air.

Data Analysis & Visualizations

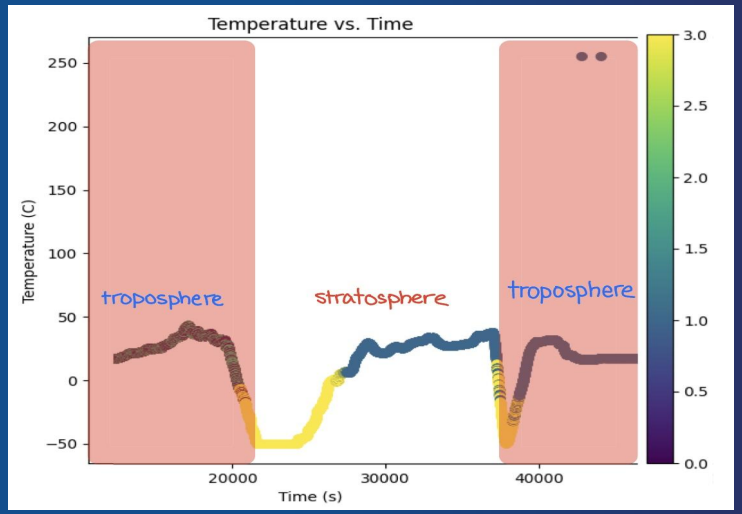
Pressure & Altitude Time Graphs

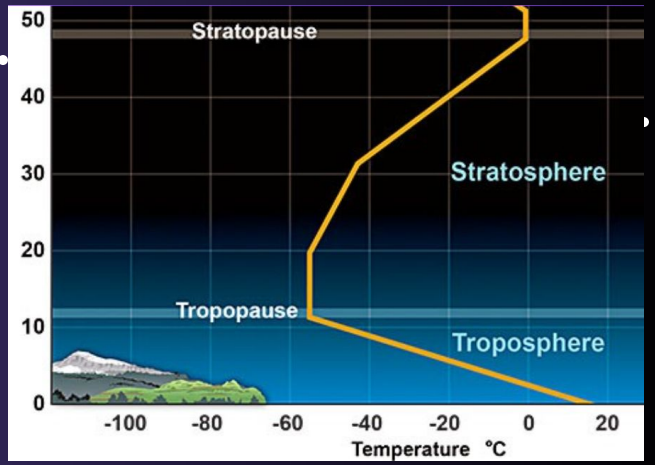


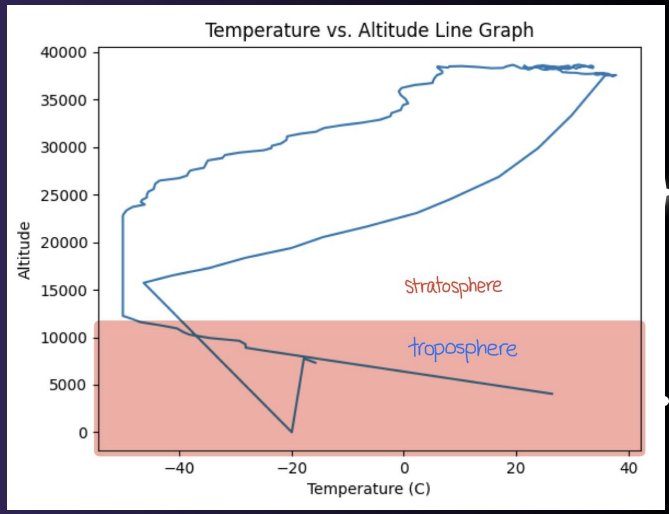


- The cluster analysis is remarkably accurate in indicating the transitions between the troposphere (green and purple) and stratosphere (yellow).
- The pressure behaved as expected, falling throughout the descent and staying stable while at float.
- Both graphs indicate that the payload landed at a higher altitude than it started, which is true based on the location data supplied by NASA.
- The altitude graph indicates the high speed at which the balloon fell after it popped because of the greater distance between data points

Temperature Graphs

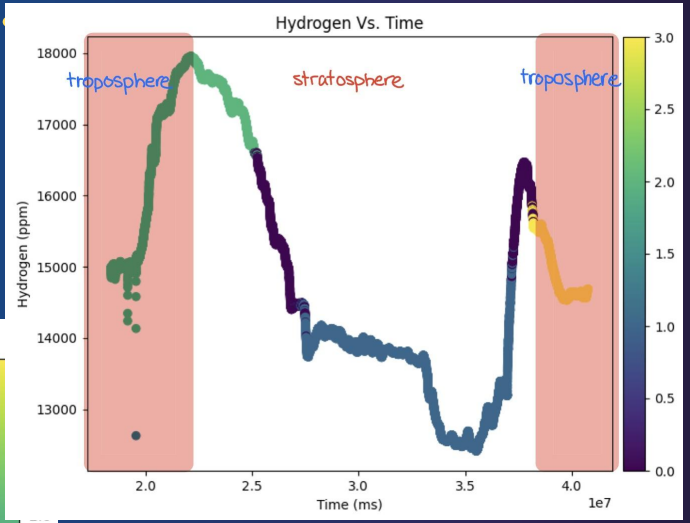


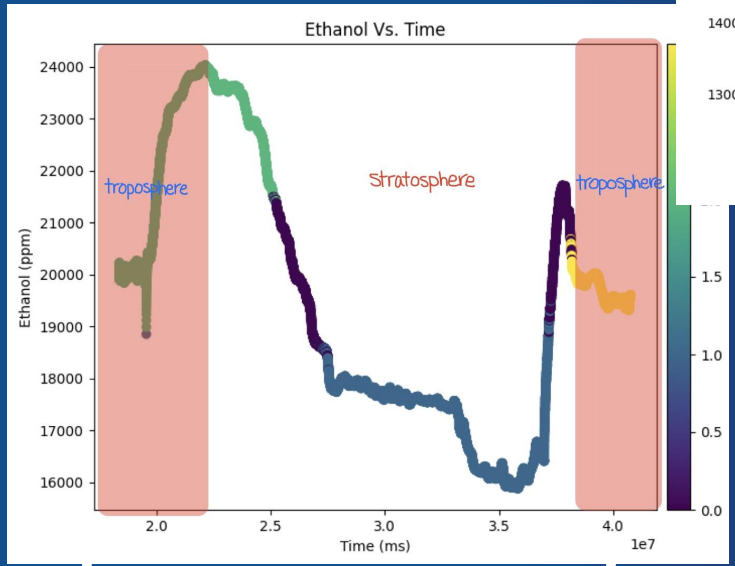




- All temperature graphs show the expected temperature variations found in the atmosphere.
- Temperature declines as the payload approaches the top of the troposphere, remains constant through the first part of the stratosphere, and then rises again until it reaches floating altitude.
- Temperature vs. Altitude is almost identical to the ideal graph on its ascent, and then changes on the descent with the change in speed

Hydrogen & Ethanol vs. Time Graphs



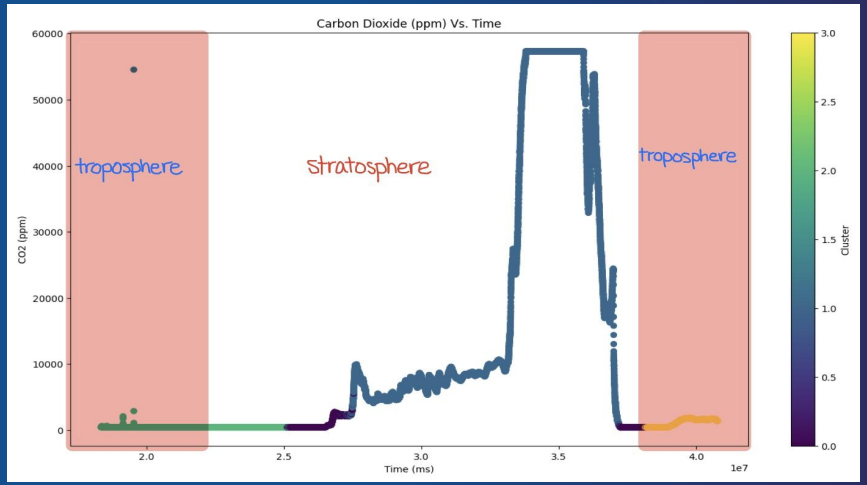


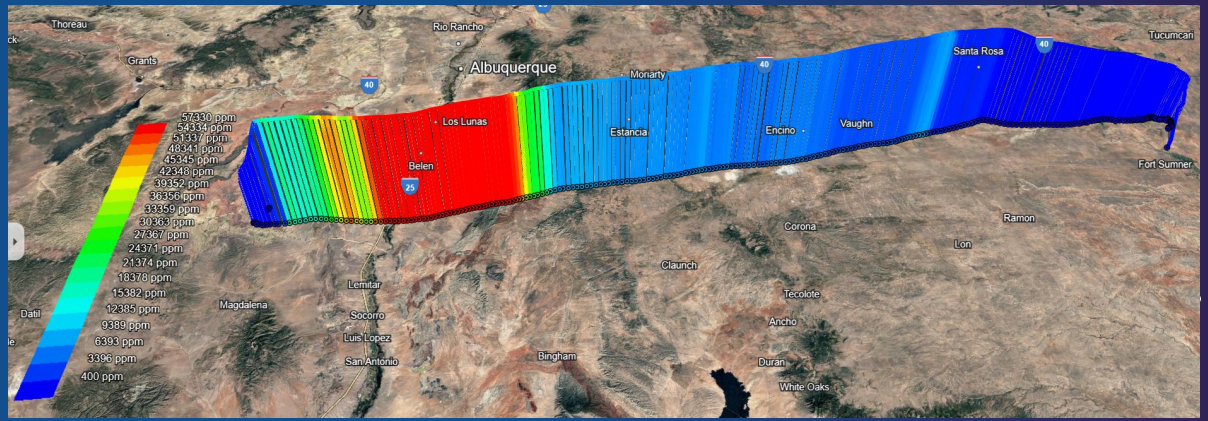
- Ethanol in the atmosphere has significantly increased over the past several decades, a result of the Clean Air Act Amendments of 1990.
- The acts mandated the use of oxygenated fuels in areas with high carbon monoxide, which exploded the sale and production of the substance.

https://afdc.energy.gov/data/10323

- For the most part, these recordings align with our expected results
- The gas levels rise at the start of the launch, but decrease as the balloon moves to higher altitudes
- The surprise with these results was the sharp decreases on both graphs between 30000 and 40000 seconds
- We did not think much of these spikes until other graphs indicated the gases may have participated in a chemical reaction
- The reaction most likely caused the gases to be competed out or used up

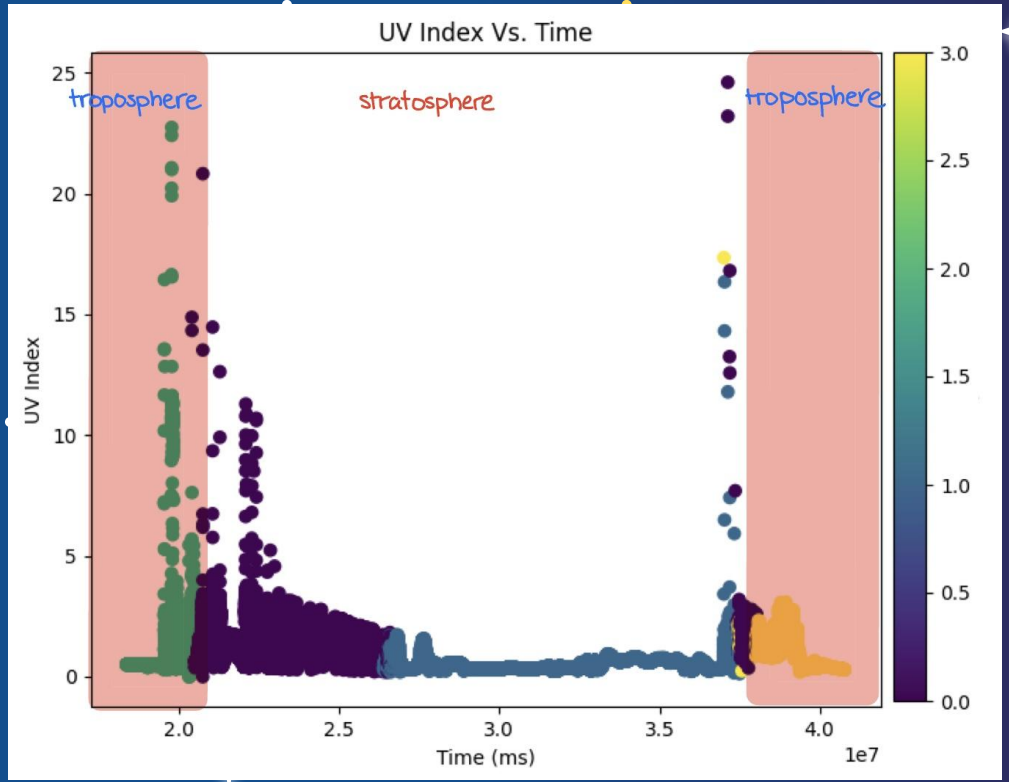
Carbon Dioxide vs. Time Graph





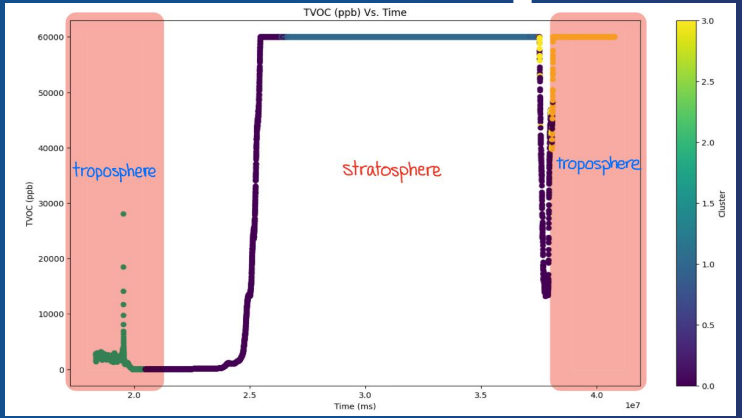
- At higher altitudes, carbon dioxide is supposed to decrease slightly or remain relatively constant
- Since the data does not line up at all with these expectations, this carbon dioxide graph made us realize that the balloon encountered something unique (either some smoke, or another carbon dioxide dense patch).
- This also explains the previous declines in the ethanol and hydrogen readings

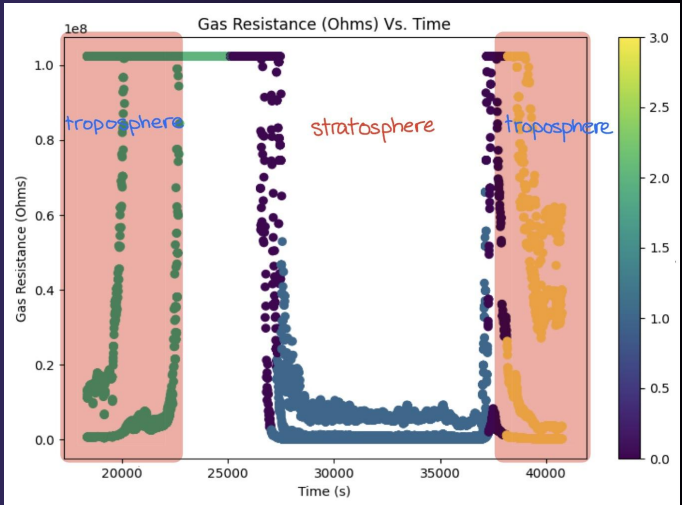
UV Index vs. Time Graph

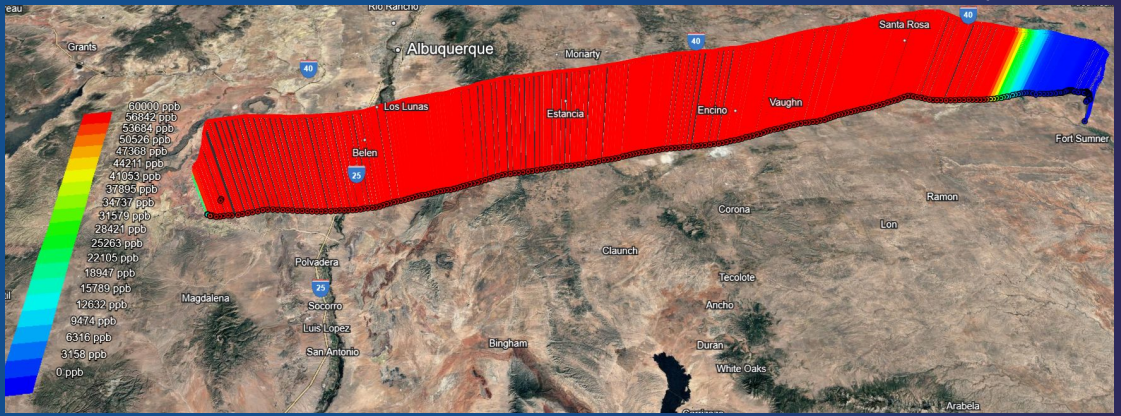


- UV Index is supposed to increase greatly after the balloon passes through the clouds and reaches altitudes in the stratosphere
- This is the second graph that greatly contradicts our expectations, and the decrease in the UV Index lines up exactly with the spike in the carbon dioxide

Gas Resistance & Volatile Compounds







- Although our BME688 gas scanning sensor did not record data in the way we anticipated, we were able to record gas resistance
- Lower gas resistance reading indicate poor air quality
- It was exciting to realize that our gas resistance and volatile compounds data all line up with our previous anomalies
- Since the anomalies were also recorded on two different sensors, we could accurately assume that the balloon passed through some kind of stratospheric intrusion

Explaining Our Atmospheric Gases Data

After realizing that the balloon passed through a stratospheric intrusion, we started research to try and determine exactly what the payload may have encountered. Because of the spike in carbon dioxide, we focused on events that release large amounts of carbon dioxide into the stratosphere.

List of the 45 volcanoes with continuing eruptions as of 16 August 2024

Volcano	Country	Eruption Start Date	Last Known Activity	WVAR
Karymsky	Russia	2024 Jun 20	2024 Aug 16 (continuing)	Yes
Kanlaon	Philippines	2024 Jun 3	2024 Aug 16 (continuing)	Yes
Whakaari/White Island	New Zealand	2024 May 24	2024 Aug 16 (continuing)	Yes
Ubinas	Peru	2024 May 6	2024 Aug 16 (continuing)	
Taal	Philippines	2024 Apr 12	2024 Aug 16 (continuing)	Yes
Lewotobi	Indonesia	2023 Dec 23	2024 Aug 16 (continuing)	Yes
Reykjanes	Iceland	2023 Dec 18	2024 Aug 22 (continuing)	
Marapi	Indonesia	2023 Dec 3	2024 Aug 16 (continuing)	
Mayon	Philippines	2023 Apr 27 ± 2 days	2024 Aug 16 (continuing)	
Etna	Italy	2022 Nov 27	2024 Aug 16 (continuing)	Yes
Ebeko	Russia	2022 Jun 11	2024 Aug 16 (continuing)	Yes
Rincon de la Vieja	Costa Rica	2021 Jun 28	2024 Aug 16 (continuing)	Yes
Great Sitkin	United States	2021 May 25	2024 Aug 16 (continuing)	Yes
Merapi	Indonesia	2020 Dec 31	2024 Aug 16 (continuing)	Yes

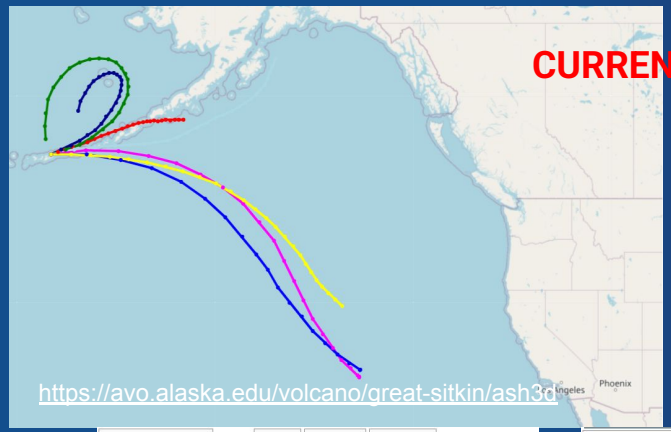
14 August-20 August 2024 — Cite this Report

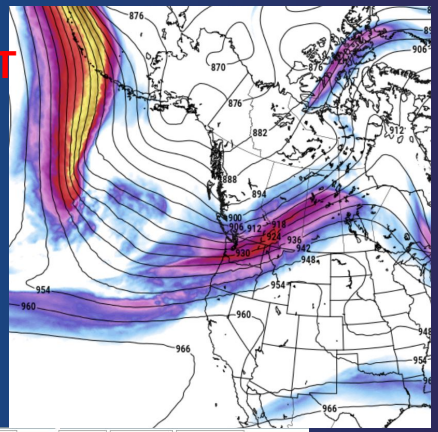
AVO reported that slow lava effusion in Great Sitkin's summit crater continued during 13-20 August. Seismicity was low with few small daily earthquakes. Slightly elevated surface temperatures were identified in partly cloudy satellite views during 18-19 August. Weather clouds often obscured satellite and web-cam views. The Volcano Alert Level remained at Watch (the third level on a four-level scale) and the Aviation Color Code remained at Orange (the third color on a four-color scale).

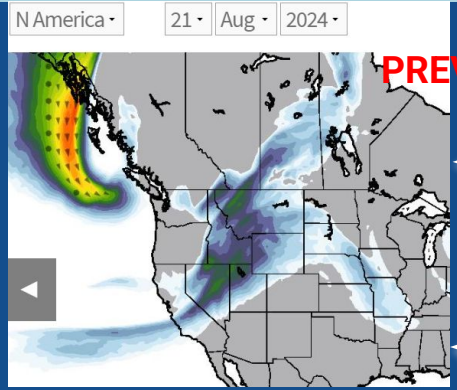
Source: US Geological Survey Alaska Volcano Observatory (AVO)

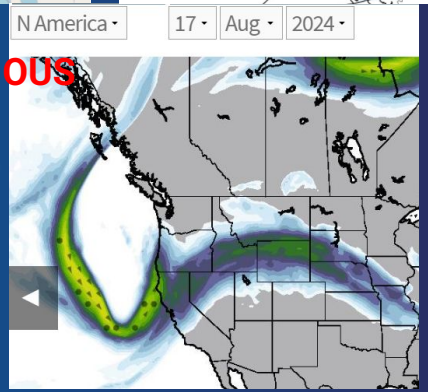
- Volcanoes are one of the most common causes of spikes in atmospheric carbon dioxide
- Volcanic emissions would also explain the decrease in the UV index because sulfur dioxide (a gas found in volcanic emissions) interacts with UV
- The emissions would also be recorded around the same altitude as the balloon float altitude
- We discovered that the closest volcanic activity to the balloon was from the Great Sitkin volcano in Alaska (Aug. 13-20, 2024)
- The Great Sitkin has been experiencing small eruptions throughout the summer of 2024

Explaining Our Atmospheric Gases Data Pt. 2



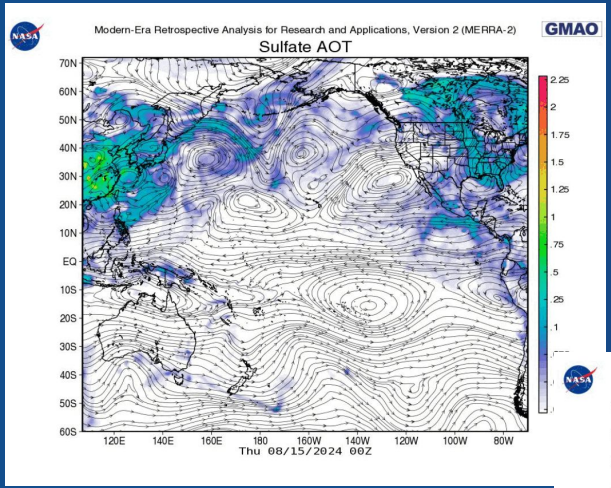


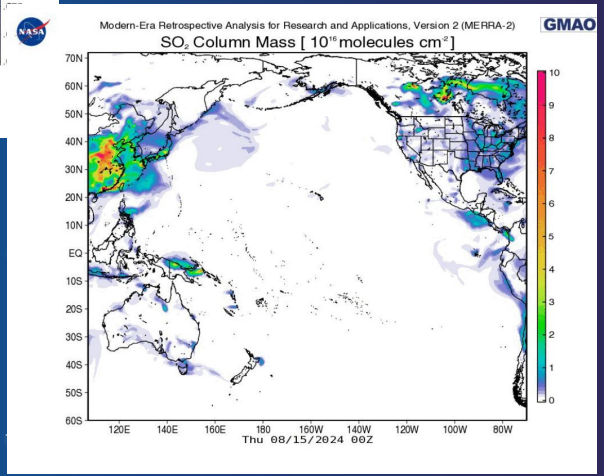




- After discovering the Great Sitkin volcanic activity, we looked at jet stream data to determine if the volcanic emissions could be the stratospheric intrusion that our data picked up
- The trajectories of the volcanic emissions line up with the jet streams, both heading towards southwestern U.S. states
- We could not find the volcanic emissions trajectory for the time of the launch. However, since the current emissions follow the current jet stream data, we can conclude that the volcanic emissions before the launch most likely followed the jet stream into the southwest United States

Explaining Our Atmospheric Gases Data Pt. 3





Oxidation of SO2 in the air results in the creation of sulfite and sulfate in the atmosphere.

- The rate of reaction increases at higher temperatures and humidity levels.

SO2 emissions could have a significant impact that could cause cooling on Earth, due to the formation of sulfate particles that more effectively scatter solar radiation from the Sun.

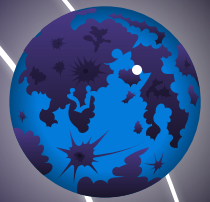
- A high presence of SO2/sulfate would lower the UV index, which is consistent with our data.

Conclusion

What We Learned:

- During our development process, we learned and developed our skills in soldering, circuitry, and sensor programming, discovering how to connect and control our sensors to effectively gather data.
- After gathering our data, we gained experience with reading, analyzing, and manipulating data. This allowed us to connect our data with real time weather patterns to determine the cause of our inconsistencies.
- Collaboration was key to our success, each of us taking on a role within one project allowed us to effectively and efficiently use our limited time and individual skills.

Thank You



Sources

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http://weather.uwyo.edu/upperair/uamap.shtml

Emissions Data by the US Department of Energy
https://afdc.energy.gov/data/10802
Ethanol:
https://afdc.energy.gov/data/10323
https://afdc.energy.gov/data/10331