Solar Eclipse Induced Atmospheric Turbulence Effects on High Altitude Balloons

Denise Buckner, Nirmal Patel, Ronald Fevig
University of North Dakota, University of North Florida

Abstract

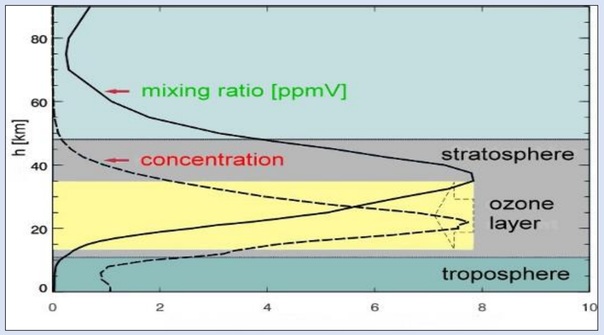
During the total solar eclipse on August 21st, 2017, the North Dakota Atmospheric Education Student Initiated Research (ND-AESIR) team launched a high altitude balloon in Rexburg, Idaho. An ozone sensor developed and fabricated by the University of North Florida (UNF) was launched to test the effect of a solar eclipse on ozone production. This sensor has been developed and tested for the past 10 years as part of a NASA HASP (High Altitude Student Platform) team collaboration between UNF and the University of North Dakota. It contains eight nanocrystalline oxide semiconductor film arrays that take simultaneous measurements of ozone concentrations. Measurements are sent to a battery operated electronic data logger. It was hypothesized that ozone production would drop during the eclipse, since ozone in the stratosphere is generated in the presence of UV light coming from the Sun. The balloon launched after the eclipse had began, and climbed during totality. It was observed that ozone concentration decreased during the entirety of the flight, with a sharp dip in production during the time of totality. This supports the hypothesis that reduction in UV light from the Sun leads to a reduction in ozone production. Observed results were similar to decreases in ozone concentration measured during night HASP flights. Further studies are required at higher and steady altitude balloon flights to better collect ozone production profiles during solar eclipses, hopefully to be conducted during future eclipses.

Ozone Sensor Operations

- Sensor consists of 8 nanocrystalline indium tin oxide (ITO) array sensors,
- ITO sensors contain electron vacancies
- In the presence of oxidizing gases like ozone, electron vacancies on the ITO film sensors interact
- O_3 binds to the film
  - Oxygen vacancy (V) + Ozone (O3) →Lattice Oxygen site (Oo) + O2
- This leads to depletion of electrons in the ITO, causing an increase in electrical resistance of the ITO film

Stratospheric Ozone Production

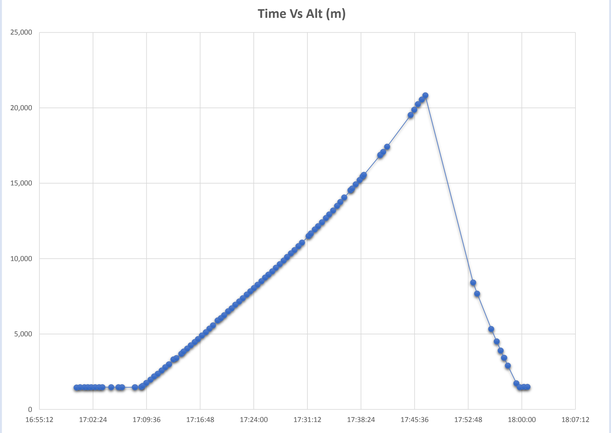
- Ozone is produced in the stratosphere in the presence of UV radiation
- UV rays break up O_2 molecules into 2 oxygen atoms
- These free O molecules bind with O_2 to produce O_3
  - $O_2 + UV \rightarrow 2\ O$
  - $O + O_2 \rightarrow O_3$

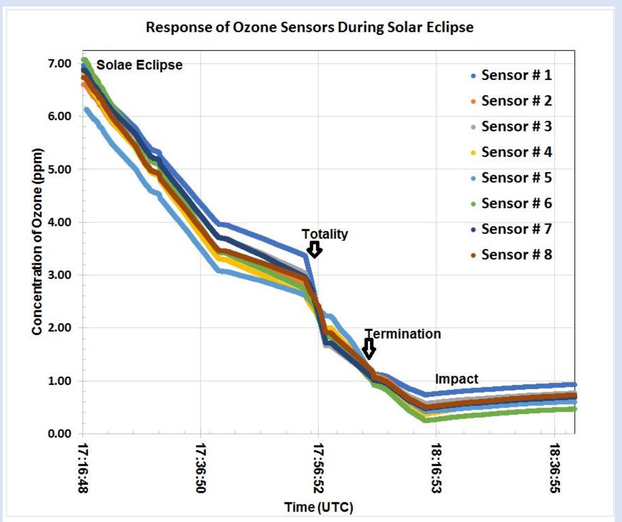


http://www.atmosphere.mpg.de/enid/1yy.html)
(ppmv = parts per million by volume = volume mixing ratio)

Eclipse Flight and Data

- Ozone sensor was flown on the UD- AESIR high altitude balloon during the total solar eclipse in Rexburg, ID
- The balloon was projected to rise through the atmosphere up to approximately 30,000 meters, similar to past HASP flights
- It was expected that the sensor would observe a dip in ozone production during the eclipse due to reduction in UV radiation in the upper layers of the atmosphere as the moon processed in front of the sun

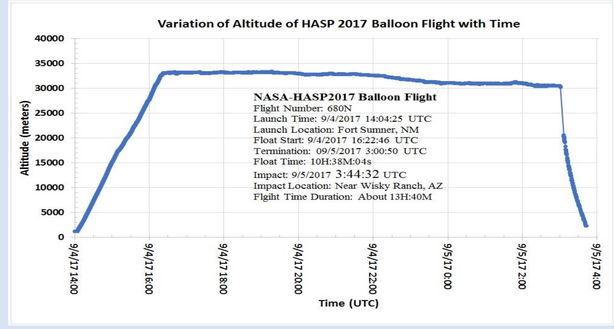


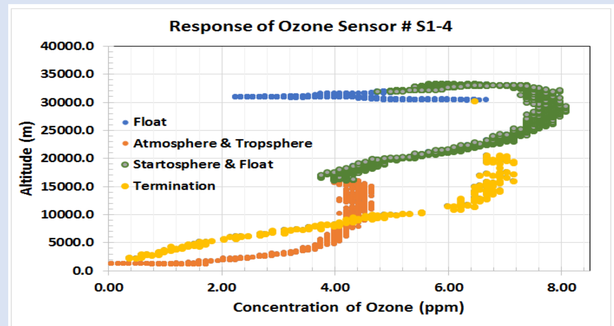


Flight Results

- Flight began at 11:00 MST (17:00 UTC)
- Decline in ozone production was observed
- At 11:33 MST, totality occurred. Altitude: 20, 818 m (68, 301 ft)
- During totality, a drastic drop in ozone concentrations occurred
- After totality, concentration continued to drop as the ascent continued
- 17 minutes after totality, the balloon experienced atmospheric turbulence, and the parachute separated from payload train
- Upon landing, ozone production was observed to increase very slightly, due to smoke in the air from nearby wildfires

HASP Flight Profile

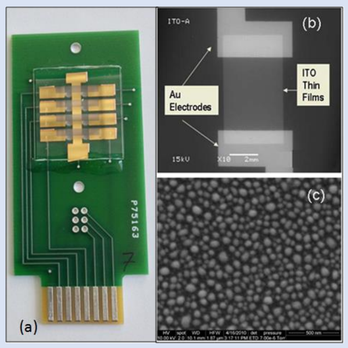




Conclusion

The hypothesis was partially confirmed: a drastic dip in ozone production was observed during totality. Ozone production declined throughout flight, but as the balloon was not at a stable altitude during entirety, exact effects of eclipse procession are unknown. Further testing is needed at the next eclipse. Wildfire smoke also interfered with ozone production, and its effects should be studied.

Acknowledgements: The presenters would like to thank the North Dakota, Montana, and National NASA Space Grant Consortiums for their support.



Light intensity: total solar eclipse