MEASURING AERSOLS AND GASES IN EARTH'S STRATOSPHERE

CLIMATE AND THE STRATOSPHERE

Motivated by a changing climate, there is growing international consideration of solar climate intervention through the release of aerosols into the lower stratosphere. In response to the need for more information, a Sandia project developed an accessible, transparent platform to make in situ measurements in the lower stratosphere. Data acquired from this atmospheric measurement platform can be used to define a 'baseline' state function of the lower stratosphere with respect to aerosols, gases, and temperature.

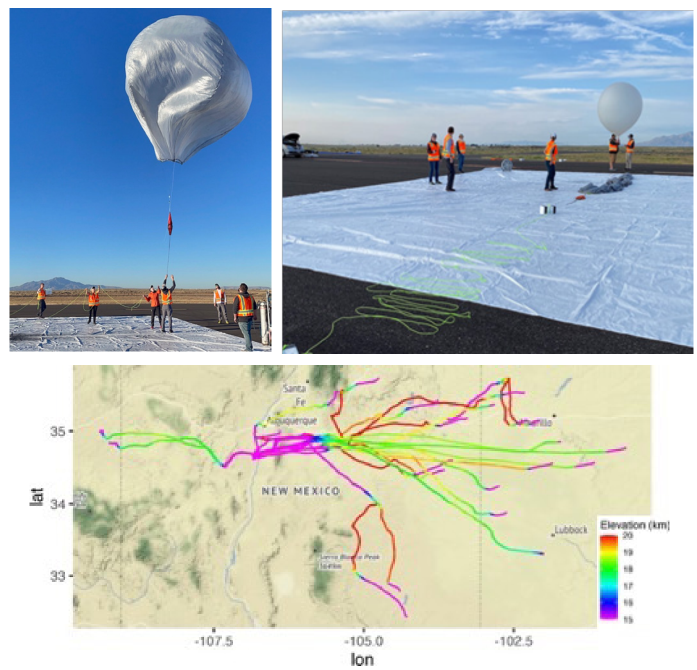
This project took place in central New Mexico. Data was obtained from 22 flights of solar heliotrope balloons capable of flying payloads less than 6 pounds up to 17-23 km above Earth's surface for 4-12 hours in daytime free float. The instruments used were International Met Systems radiosonde temperature sensors, a Sandia-developed gas sampler, and modified Alphasense Optical Particle Counters.

The temperature sensors were found to be positively biased compared to global reanalysis data sets. The gas sampler was able to collect gases from the stratosphere and hermetically seal the sample for later analysis, but with the risk of contamination from the solder valve as identified in Gas Chromatograph Mass Spectrometer analysis. The Optical Particle Counters measured aerosols in the lower stratosphere in a reliable way, and results compare well to other studies.

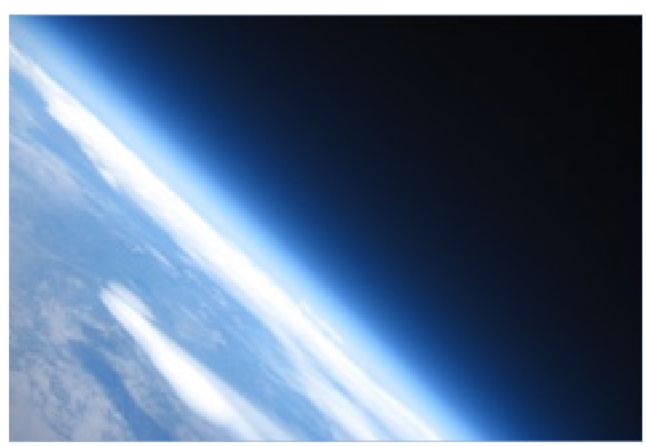
In conclusion, this project standardized an atmospheric sampling platform that can be used to collect data on the base-state of the lower stratosphere or used to analyze targeted aerosol-emitting events, such as volcanic eruptions and smoke plumes from wildfires.

SOLAR BALLOON CAPABILITIES

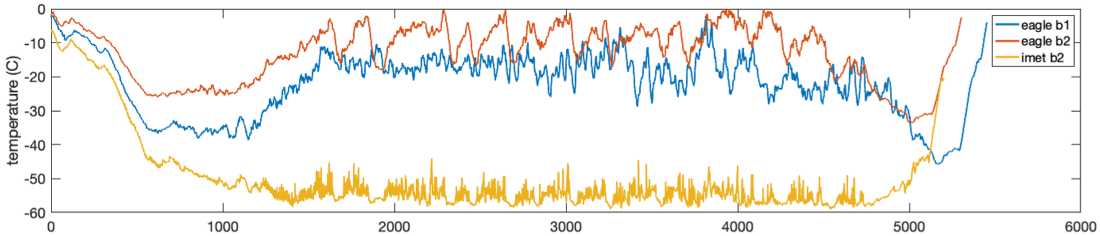
The solar hot air balloons used in this project typically reached the lower stratosphere. Central New Mexico winds vary on a biannual basis, flowing westward in summer and eastward in winter. Tropospheric winds are normally strong and easterly in winter, with occasional shifts northwards or southwards. In the summer, they tend to be weak and variable. Most of the project's solar hot air balloon flights were not in the summer, resulting in mostly eastward flight paths. The team terminated some flights at the New Mexico-Texas border to prevent long recovery trips. Trajectory predictions were used to de-risk flights. When predictions showed intersections between the flight path and restricted airspace or large population centers, the launch was not pursued until the risk decreased.



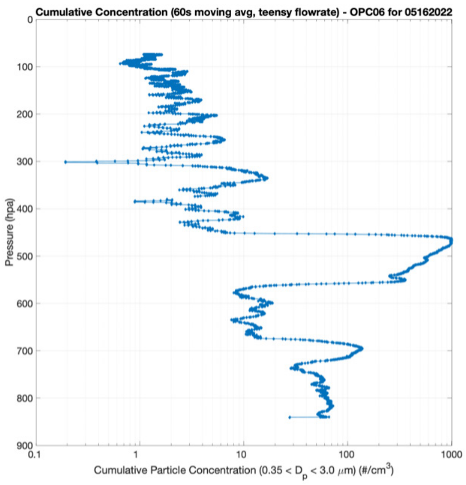
A solar balloon lifting off during a launch on a sunny day with low surface winds, ideal launching conditions (top). The flight paths for the 22 solar hot air balloons launched during this project (bottom).



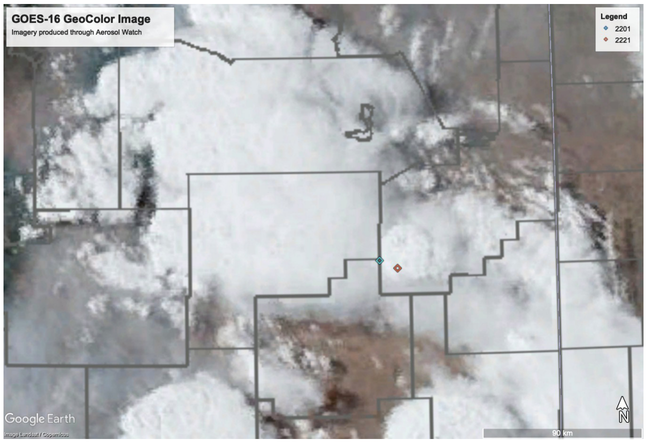
A view of central New Mexico taken from a solar balloon 78,000 feet above ground level.



Temperature data from the Campaign 01 flight, February 8, 2020. The 'eagle b01' and 'eagle b02' show over 40°C higher temperatures than the iMet sensor due to a combination of radiative heating of the instrument probes and their proximity to insulated packaging.

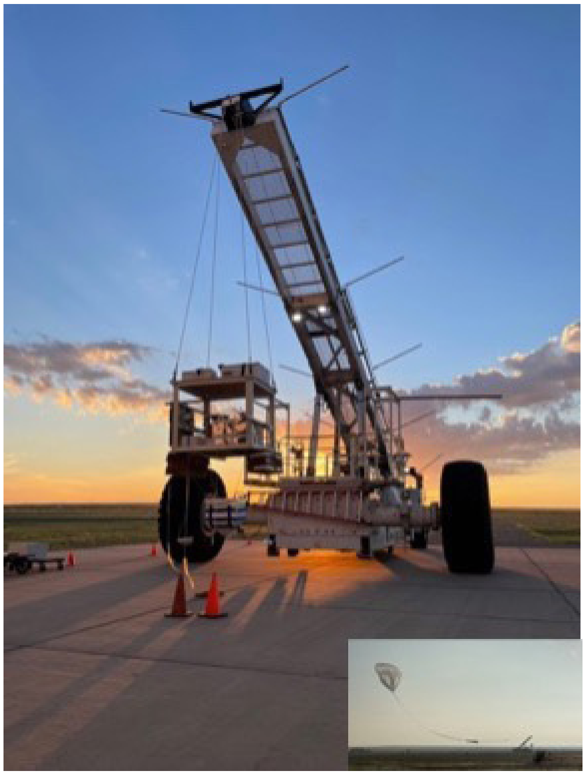


The cumulative particle concentration on ascent was calculated using a linear flow rate correction and an exponential flow rate correction.



A map of a balloon launched on May 16, 2022 at the time of ascent in blue and during its flight in orange generated using Google Earth and GOES16 GeoColor satellite imagery from AerosolWatch.

The instrumentation tested and designed for the Sandia heliotrope flight platform was prepared on a NASA gondola during a zero-pressure balloon engineering test flight.



NASA gondola and 'Big Bill' during a hang test in Ft. Sumner, NM and (inset) zero pressure balloon launch.

FUTURE DIRECTIONS

The success of this project provides many opportunities for follow on research. Specifically, building on the research in this project would ideally include future flights to build out these initial baseline datasets, targeted campaigns to measure perturbations of interest, additional characterization work for the various sensors in the laboratory and environmental chamber, the addition of telemetry into the each of the sensors, and interpretation and validation of these datasets.

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