Arkansas BalloonSAT: Nine Years & Counting
Arkansas BalloonSAT

Outreach

• ~ 20 Middle, Junior, & High Schools actively participate
• CricketSATs
• Payload Boxes for balloon flights
• Science fair projects
Arkansas BalloonSAT

Outreach

• Teachers and students participate in balloon launches

• EAST Initiative Schools
  (Environmental and Spatial Technology, Arkansas, Iowa, Louisiana, Oklahoma and Pennsylvania)
Arkansas BalloonSAT

Outreach

- Arkansas Science Festival
- UAMS’ Science Café
- KUAR FM89.1 Call-in Radio Show
ABS-07, 5-24-2008

- Abs Humidity g/m³
- Light Intensity (V)
- Temperature (°C)

Tropopause

Stratosphere

Balloon Burst
Mid-level to College Students preparing for a launch on the ASTATE Beebe campus
Students, Teachers, & Faculty preparing payloads for launch.
Arkansas students are collecting atmospheric data using sensors suspended from trees. More information can be found by clicking on the school page listed in the sidebar. Pictures can be found under files.
Pottsville High School

Date this measurement was made *
The date to record here is the actual date of the sensor measurement:

Month ▼ Day ▼ 2015 ▼ 31

Time this measurement was made *
The time to record here is the actual time the sensor was turned:

Hr ▼ : Min ▼ AM ▼

Time stamp of data being reported *
This measurement is in milli-seconds as reported during data collection:


Temperature Data Reading *
### Pottsville High School (Responses)

<table>
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<th>Date this measurement was made</th>
<th>Time this measurement was made</th>
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Our Changing Earth

In this issue:
- Redefining Earthquakes
- Students at the Edge of Space
- Raining Down on Safety!

Visit www.nsta.org
to find more resources for science educators
ABS-5 Burst
Student Research

- Ideal Gas Law
- Radiation and the Magnetic Field
- Payload Box Design
- Light Intensity in Different Colors
AnaSonde
GPS (latitude, longitude, vertical & horizontal speed),
Pressure, Temperature, &
Geiger Counter
Light Intensity Measurements
Solar Panel Calibration

- Light source above ice water bath.
- HOBO Logger measure light intensity, solar panel voltage and temperature.
- Create a temperature correction factor.
- Solar panel generate higher voltage at lower temperatures due to lower resistance.
Light Intensity Profile

![Graphs showing light intensity profile vs altitude and light intensity.](image)
BalloonSAT: High Altitude Methane Measurements
Jennifer Sullivan, Bryant Fong, Tillman Kennon
Arkansas State University, Jonesboro, AR 72401

Introduction

- Methane (CH₄) is the third most important greenhouse gas after carbon dioxide and water. It plays a key role in tropospheric chemistry, and therefore in air quality issues through oxidation by hydroxyl (OH) radicals.
- High altitude concentrations are suspected to increase because ground level methane measurements have increases and expected to reach 1873 ppm by 2020, a 14% increase of 1984 levels at current trends.

Figure 1: Ground level methane measurements from the Mona Loa observatory in Mona Loa, HI. Methane concentrations measured by evacuated flasks. On graph monthly values (blue) and yearly samples per launch.

BalloonSAT Program

BalloonSAT is an educational outreach and scientific research program at the Arkansas State University (ASU) that uses weather balloons that reach into the lower stratosphere (87,000 ft, 25km) for high altitude experiments. Launches consist of payload boxes with high altitude experiments as well as instruments that measure atmospheric temperature, water vapor (as humidity), pressure, methane, and carbon dioxide concentrations throughout the air column. GPS recorder for balloon tracking allow for real time altitude updates and recovery once balloon returns to Earth’s surface. Measurements of water vapor content and vertical temperature profiles correlate with other high altitude studies.

Figure 4: Weather balloon inflation before launch. Payload boxes are placed onto table and attached to balloon before liftoff.

Method

- Arduino is an open-source single board computer using a Java environment coding structure.
- A SD card allows for larger data storage and expedited data extraction.
- MQ-2 detects liquefied petroleum gas (LPG), methane and smoke (incompletely burned biomass)
- MQ-6 detector detects butane, LPG, and propane.
- Changes in gas concentration and temperature create proportional changes in resistance of sensors
- Data reads out on display to confirm detector operation.
- Measurements are taken every 15 seconds to match transmissions and data recording of other instruments.

Figure 2: Individual components shown. (left) Arduino Uno circuit board with SD card shield which allows for larger data storage of individual methane measurements. (right) MQ-2 and MQ-6 methane detectors are attached to Arduino.

Calibration

- Calibration used 99.99% pure methane mixed with compressed air.
- Air flow controlled using digital flow meters measured in milliliter per minute (mL/min). Flow rates are translated to ppm of methane
- Calibration first done with different concentration of methane by mixing pure methane and compressed air at room temperature.
- Sensors are also sensitive to temperature, so calibration standards taken at lower temperatures to mimic conditions of upper troposphere and lower stratosphere.
- Lower temperatures achieved by immersing environmental chamber into a ice bath and ice bath with salt.
- Ambient temperature of chamber measured with Vernier wide range temperature probe and LabQuest.

Figure 5: Schematic of methane setup. Concentrations of methane controlled by mixing air and pure methane into a temperature controlled chamber with methane sensors.

Figure 6: Calibration curves of MQ-2 detector measured under laboratory controlled conditions. (a.) Detector response under varying concentrations. (b.) Detector response under varying temperature.

(a.) $y=0.2066x+506.32$, changing concentration
(b.) $y=9.037x+2106.9$, changing temperature

Results and Discussion

- MQ-6 detector not sensitive to changes in methane concentration.
- MQ-2 detector found to have linear response to both concentration and temperature.
- Arduino millivolt measurements transformed into ppb concentrations with two calibration curves. Both calibrations have high correlation values ($R^2>0.8$)

Figure 7: Methane profile measured with balloon borne MQ-2 detector.

- Concentrations of methane higher near surface due to proximity to point source emissions.
- In lower part of troposphere (5-10 km), oxidation of hydrocarbons by OH radicals make CO₂, H₂O and CH₄ products.
- An average CH₄ molecule last 8-9 years before oxidized, a long time compared to other atmospheric species.
- Around 10% of CH₄ is transported into stratosphere (15-50 km) where it is also oxidized. Since water vapor in stratosphere is low, the indirect process changes the climate impact of methane by 15%.

Summary

- Methane profiles was found to first decrease in troposphere due to increased distance from methane emissions, then decrease in stratosphere due to infrequent transport of methane from tropospheric altitude.
- Arduino based sensors collect similar methane profile measurements to other instruments with added lightweight and inexpensive benefits.
- Continuous profile measurements using balloons is advantageous to air sample because the concentration is measured throughout the air column on a single day rather than only certain altitudes.

Acknowledgements

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Figure 3: Arduino methane detector. System is mounted in a styrofoam box and launched in the BalloonSAT program.

Figure 8: Methane profile measured with balloon borne MQ-2 detector.

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Arduino methane detector. System is mounted in a Styrofoam box and launched in the BalloonSAT program.
Individual components shown. (left) Arduino Uno circuit board with SD card shield which allows for larger data storage of individual methane measurements. (right) MQ-2 and MQ-6 methane detectors are attached to Arduino.
Developing a Balloon-borne Spectrometer
Lindsey Martin, Bryant Fong, Tillman Kennon
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Introduction

- Absorbance of different wavelengths of light indicate presence and rate of various atmospheric reactions including sulfur sequestration, reactions of volatile organic carbons (VOC), polycyclic aromatic hydrocarbons (PAH), and ozone concentrations.
- VOC and PAH are critical atmospheric particles studied intensely due to their environmental health effects and point source emissions.
- Aging process changes aerosol composition, mass, number distribution and the optical and cloud condensation properties.
- Changes in aerosol size and coating will change the way aerosols reflect sunlight resulting in a relative global cooling effect.
- Ultraviolet Spectroscopy was used to measure the amount of light reflected and absorbed on different particles in the atmosphere.

UV-Visible spectroscopy

- Atmospheric absorbance and reflectance profiles were collected with an Ocean Optics USB2000 diode array spectrometer with a deuterium tungsten filament light source and Sony ILX511 linear silicon CCD array detector (fig 3).
- Light enters the spectrometer (1) controlled by a slit (2) and filter (3). The filtered light reflects on a collimating mirror (4) onto a diffraction grading (5) that reflects light to a focusing mirror (6) onto collector lens (7) and detector (8).
- Payload box contain spectrometer, fiber optic cable and netbook.
- Spectrometer is powered by netbook computer via USB.
- Data collected onto a netbook about every minute using Vernier LoggerPro software from spectral range 220-860.
- Payload box is suspended from a 1200 gram latex balloon ascended to 100K ft (30 km) before returning to surface.
- Two successful flights were made before netbook was destroyed in a water landing in third flight.
- Data was collected through ascent one flight. Software stopped data collection after ten minutes during first flight.

Future Endeavors

- Previous laptop was heavy, difficult to set up in field and prone to damage from water and expensive to replace.
- Future work to interface spectrometer with Raspberry Pi (left) or with tablet computer.
- The Raspberry Pi is a fully functional Linux OS computer with and ARM processor, one HDMI port, and two USB ports.
- Python programming to execute Java codes is planned with the spectrometer as a single DFOV object.

Summary

- Initial measurements show eight distinct trends indicative of the atmospheric reactions, pathways and particles at that altitude.
- Spectrometric measurements are important to identify presence and rate of different atmospheric reactions, pathways or particles.
- Current efforts attempt to interface spectrometer with a tablet to operate spectrometer more efficiently in field and at a lower weight.

Acknowledgements

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Figure 1: Light scattering changes when primary aerosols age as a result of coating which increases the size and composition of the primary aerosol.

Figure 2: Schematic of USB spectrometer

Figure 3: General trends observed from spectrometer. Y-axis absorbance units and X-axis is altitude (km). Higher absorbance translates to lower transmittance.

Trends seen from flown spectrometer across two flights. Data on the following tables comes from ABS 25. The x-axis is altitude in feet, while the y axis is absorbance units, maximum absorbance is one. Li measurements with spectrometer, numbers are wavenumber with accompanied description if exists:

(a) 222 This is the trend for UV.
(b) 297
(c) 329 this is the color violet in the visible spectrum
(d) 388
(e) 483, cyan maxes out detector. The sky is blue. 
(f) 591, the color yellow
(g) 644, the color red. This matches measurements with colored filters
(h) 723, reaches into the N-IR spectra, this appears to follow the trends seen in the solar panels. All noise in the measurements are from a spinning box.
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