TEMPERATURE AND OZONE AS A FUNCTION OF ALTITUDE

by

Adam Worden

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DEPARTMENT APPROVAL

of a senior thesis submitted by

Adam Worden

This thesis has been reviewed by the research committee, senior thesis coordinator, and department chair and has been found to be satisfactory.

_________________________  ____________________________
Date                      J. Ryan Nielson, Advisor
_________________________  ____________________________
Date                      Kevin Kelley, Senior Thesis Coordinator
_________________________  ____________________________
Date                      David Oliphant, Committee Member
_________________________  ____________________________
Date                      Todd Lines, Committee Member
_________________________  ____________________________
Date                      Todd Lines, Chair
ABSTRACT

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Adam Worden
Department of Physics
Bachelor of Science

An analysis is provided of the atmospheric conditions of the troposphere and lower stratosphere above Idaho. Temperature and ozone and as a function of altitude are determined. The data shown was acquired over the summer of 2017 and the winter of 2019. It was analyzed afterward and $\chi^2$ was also determined. A numerical model for temperature and ozone as a function of altitude was created and compared to the U.S. Standard Atmosphere.
I’d like to thank my research mentor Brother Nielson, my team in the High Altitude Research Team, Aileen Godfrey for starting the High Altitude Research team and for giving me opportunities to create. I’d especially like to thank Lydia Harris for being my sounding board. I’d also like to thank Arii Jithame and Talon Dow for all the moral support.
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Chapter 1

Introduction

1.1 History

The U.S. Standard atmosphere is introduced as well as the High Altitude Research Team and its origins.

1.1.1 The U.S. Standard Atmosphere

The purpose of this paper is to describe the temperature vs altitude correlation of the Earth’s atmosphere through data compiled from five balloon launches by the Brigham Young University-Idaho High Altitude Research Team and check that the model at hand is accurate, as well as see if the Solar Eclipse on August 21, 2017 had any effect on the atmosphere. A final launch on March 30th, 2019 with the High Altitude Research Team measured ozone versus altitude and is also compared to the model.

The Earth’s atmosphere is a much more complex system than many would initially think. There are multiple layers, each with their own specific compositions and air densities. We observe from the U.S. Standard Atmospheric model [5], as
altitude increases temperature will drop but then rise again. Directly from the U.S. Standard Atmosphere, the next section describes what it entails. The U.S. Standard Atmosphere

was generated under the impetus of increased knowledge of the upper atmosphere obtained over the past solar cycle. Above 50 km, this Standard is based on extensive new rocket data and theory for the mesosphere and lower thermosphere acquired over more than one complete solar cycle ...

Part 1 gives the basis for computation of the main tables of atmospheric properties, including values of physical constants, conversion factors, and definitions of derived properties, including values of physical constants, conversion factors, and definitions of derived properties. Part 2 describes the model and data used up to 85 km, in the first section; and the model and data used above 85 km in the second section. The theoretical basis of the high altitude model is given in an appendix. Part 3 contains information on minor constituents in the troposphere, stratosphere, and mesosphere. The main tables of atmospheric properties to 1000 km are given in Part 4. The international system of metric units is used. [5]

1.1.2 NASA’s Model For Our Atmosphere

As shown in Figures 1.1, 1.2, and 1.3 the model for our atmosphere in regards to temperature and ozone are dependent on altitude. Figure 1.3 presents the mathematical model of the Earth’s atmosphere developed by NASA. This model will be one of the models to which I will compare my data.
Figure 1.1 The U.S. Standard Atmospheric model for Ozone versus Altitude
Chapter 1 Introduction

Figure 1.2 The U.S. Standard Atmospheric model for Temperature versus Altitude [5]

Figure 1.3 NASA's model for our lower atmosphere. [2]
1.1.3 The Formation of the High Altitude Research Team

The formation of the High Altitude Research Team surrounded the event of the August 21st, 2017 solar eclipse that occurred directly above Rexburg Idaho. As a founding member of the team, I was in charge of the payload items and the fill system for a time. Aileen Godfrey [4] was the head of the entire team. It was under her direction that the five launches included in this thesis happened. The five launches, including the solar eclipse, were a pivotal part of my experiment.

1.2 The Instruments Used

The instruments I worked with were the Trackuino and the En-Sci Model 2Z Ozonesonde [3] paired with the iMet Radiosonde. These instruments were the experimental basis of my experiment.

1.2.1 The Trackuino

The High Altitude Research Team needed a tracking solution for the balloon launches. I was in Physics 250 Lab when I stumbled upon the invention. I decided to research more about it and built the instrument. It was an Arduino based tracker that was perfect for my project. The tracker was built and worked after some troubleshooting. It took time to solder the individual parts together. Uniformly, the whole instrument is called an Arduino “shield.” It’s capabilities are that it reports GPS coordinates well above our range up to about 19 km. The board supports a Radiometrix HX1 (300 mW) transmitter which broadcasts standard APRS position messages (latitude, longitude, altitude, course, speed and time). It also includes external and internal temperature sensors.
1.2.2 The Ozonesonde

The ozonesonde was an En-Sci Model 2Z. [3] This instrument uses an electrochemical process that generates electrical current in proportion to ozone concentrations. The instrument records ozone from the difference in the concentration of the potassium iodide solutions in the instrument’s cathode and anode chambers. When ozone enters the sensor, iodine is formed in the cathode half cell. The cell then converts the iodine to iodide, a process during which electrons flow in the cell’s external circuit. By measuring the electron flow (i.e., the cell current) and the rate at which ozone enters the cell per unit time, ozone concentrations can be calculated.

The En-Sci Model 2z [3] is compatible with InterMet Radiosondes. The radiosonde provides a means of sending telemetry down to the ground and updates the data in real time. The radiosonde also measures temperature, humidity, pressure, and even acquires GPS longitude, latitude, altitude, and speed data.

1.2.3 The High Altitude Research Team

“The Brigham Young University-Idaho Physics Department worked to launch weather balloons into the stratosphere for research purposes during the 2017 solar eclipse, from inside the zone of totality. Tandem balloon flights for eclipse research purposes were executed in conjunction with Weber State Universitys High Altitude Reconnaissance Balloon for Outreach and Research (HARBOR) team. This project led to the creation of the BYU-Idaho High Altitude Research Team (HART).” [4] The High Altitude Research Team comprises of payload and tracking teams. The payload team is in charge of assembling payload items such as the Trackuino, Ozonesonde, and many other student-led projects and making sure they are launched into the stratosphere. The tracking team is in charge of finding this payload after the balloon has burst or
1.2 The Instruments Used

A cut down system has severed the balloon from the payload. Using various tracking methods, the tracking team hunts for the payload and retrieves it so the projects and their data recorded and saved on SD cards can be read and analyzed.
Chapter 2

Methods

Trackuino assembly, Payload and Launch Assembly for HART, and Data Collection are found in this chapter. Methods such as how the Trackuino works and how the ozonesonde is prepped are described.

2.1 Trackuino Assembly

The purpose of the Trackuino was to have a solution to tracking the high-altitude balloon. The Trackuino option would use the Automatic Packet Reporting System (APRS) and send the whereabouts of the balloon to a computer. This way we would be able to know where the balloon is at all times. Ordering the parts for the Trackuino was easy. Other procedures include coding and assembling the Trackuino shield, this includes soldering and other assembly. Possible difficulties were manufacturing defects, bad soldering, bad antenna design, not having an amateur radio license, and many other things. The course project required a proposal and an estimated cost for the parts.
2.1.1 Parts

A parts list was compiled with the estimated cost and number of units we would buy. See Figure 2.1.

2.1.2 Soldering the Trackuino

The soldering for the Trackuino shield was simple, in concept, but complicated in practice. There was a certain order in which the parts had to be soldered, including pieces that were tinier than the head of a pin.

2.1.3 Troubleshooting the Trackuino

The Trackuino should never be turned on without its radio antenna attached. Without it, the power radiated by the Radiometrix HX1 will reflect back and will overheat the HX1 itself and/or the entire board. The entire code for the Trackuino is on Github. [7] It is an open source project and the steps to operate the shield and upload it to the Arduino are simple. First, download the code from Github itself. It needs to be extracted from a zip file in order to work. Open the Arduino file and go straight to the config.h folder. Within this folder is where you add your amateur

<table>
<thead>
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<th>Quantity</th>
<th>Cost per unit $</th>
<th>Total Cost $</th>
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</thead>
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<td>49.95</td>
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<td>Arduino 8 pin male-female headers</td>
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<td>2.54</td>
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</tr>
<tr>
<td>Radiometrix HX1</td>
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<td>50.99</td>
<td>50.99</td>
</tr>
</tbody>
</table>

Figure 2.1 Trackuino Parts List
radio call sign. This call sign is for the APRS and amateur radio identification. Without it, it is illegal to transmit and use the Trackuino. Among other things you can change your transmitting interval and even whether to broadcast in degrees Celsius or Fahrenheit. The Trackuino was the instrument that collected the temperature data for the five flights of 2017.

2.2 Payload and Launch Assembly for High Altitude Research

The HART launch procedure is as follows: First, we lay down the tarp and secure it. Once the payload line is ready, the launch team attach whatever “fill nozzle” is appropriate for the balloon to the fill line. The nozzle differs for each balloon because the size of the balloon necks differ. The launch team then slips the cut-down loop over the fill nozzle and then fit the fill nozzle to the balloon neck. See Figure 2.2. We secure the neck by wrapping it with duct tape. We then start the fill process. The ballast is used as a counterweight to correctly measure the buoyancy of the balloon once its filled. The ballast should be 150 percent of the total weight of the payload plus the parachute. Once the ballast is at equilibrium, the fill stops. See Figure 2.3. The balloon is secured in my hand and the duct tape is removed. Before the duct tape is removed though, the launch team slips the cut-down loop above the duct tape. The balloon neck is then folded onto itself, the cut-down loop being within the fold. I then have a helper wrap the balloon neck with duct tape. See Figure 2.4. The balloon is now ready to be launched.
Figure 2.2 The balloon fill process where the payload and fill nozzle are attached to the balloon.

Figure 2.3 The balloon being filled with the ballast below.
2.2 Payload and Launch Assembly for High Altitude Research

![Image](image_url)

**Figure 2.4** The finishing duct tape to secure the payload to the balloon and send it upwards.

### 2.2.1 The Trackuino Payload

The Trackuino assembly consists of the Arduino, the Trackuino Shield, the GPS antenna, the radio antenna, a lithium ion rechargeable battery pack, the USB connection cable, and external temperature sensor connected to the shield. The external temperature sensor should always be outside of the payload box.

### 2.2.2 Trackuino Preparation

To prepare the Trackuino, simply make sure all the antennas are connected properly. To flash the firmware on the Trackuino, remove the Venus GPS or the entire Trackuino shield. The purpose of flashing the firmware is to make sure the Trackuino is properly functioning. After flashing the firmware, plug it back in. The GPS and the host computer share the same serial port, so they will conflict when used together. The Trackuino program will not be successfully uploaded unless these steps are taken. To know if the Trackuino is successfully transmitting, the red LED on the Venus GPS chip will start to flash.
2.2.3 Ozonesonde Preparation

The ozonesonde preparation is very complex. First, the anode and cathode solution has to be made. This is with a chemical solution of different salts. The ozonesonde sensor solution should be prepared from reagent-grade chemicals and double or triple distilled water. The cathode solution should be made first. With a 1000 $ml$ volumetric flask, add 500 $ml$ distilled water. Then add 5.00 $g$ of Potassium Iodide, $KI$. After, add 12.50 $g$ of Potassium Bromide, $KBr$. The next step is to add 0.63 $g$ of Sodium Phosphate, $NaH_2PO_4 \cdot H_2O$. Finally, add 1.87 $g$ of Sodium Phosphate, Di-basic, 7-Hydrate, Crystal, $NaHPO_4 \cdot 7H_2O$. Shake vigorously to dissolve the chemicals, then add distilled water to make up the 1000 $ml$ of cathode sensing solution.

For the anode solution, fill a 100 $ml$ plastic bottle one-half full with 50 $ml$ cathode solution. Add 70 $g$ $KI$ crystals to the solution and shake vigorously to dissolve the crystals. Some crystals will remain undissolved, indicating that the solution is saturated.

Store the solutions in dark bottles, preferably ones that block out light. Store them in dark place at around 20° to 25° $C$. After several months of storage old solution should be discarded in a safe container and new solution prepared.

To prepare the ozonesonde instrument one must make steps at least a week in advance of the flight. The initial prep is vital for good and accurate data. First take out the ozonesonde from its Styrofoam box. Record the date and the ozonesonde number. Insert the intake tube. Turn on the Ozone Test Unit. Make sure the Air Pump in ON and the Lamp is OFF. Warm up the ozonesonde pump and motor on filtered zero air. Do this by inserting the the open end of the intake tube into the Low/No $O_3$ port. Connect the ozonesonde’s power cord to the test unit’s power cord. Flip on the Ozone switch to turn on the ozonesonde. Run the sonde for ten minutes. After the allotted time, record the pump current ($mA$). If possible, record the pump
2.2 Payload and Launch Assembly for High Altitude Research

pressure \( (psi) \) by disconnecting the cathode tube (the right tube) and inserting a pressure sensor into the pump. Next, record the DMT pressure measurement \( (inHG) \). This is found on the back of the sonde in it’s information sheet.

Now begin high ozone conditioning. Bypass the cathode cell by using a pair of pliers and removing the tip. Keep the tube inserted in the pump. The cell is now bypassed. Add 5-6 cc cathode solution to the right tube. Now insert the intake tube into the High \( O_3 \) port. This is the only time the High \( O_3 \) port is used. Reconnect the power chords. Turn on the Lamp, pull the slide, and turn on the ozone pump. Run on high ozone for 30 minutes. After the allotted time turn off the Lamp, push in slide, and place the intake tube in the Low/No \( O_3 \) port. Run for three minutes. Dump the cathode rinse in a safe container. Add 3.0 cc of cathode solution. The cathode tube must be placed on the Teflon post inside the “clover.” Reinsert the end of the cathode tube to the pump. Now take off the anode tubes top (the left tube). Add 1.5 cc of anode solution. Do not touch the bottom of the cathode/anode caps. They can be picked up by their tops though. Make sure they are screwed on tight via pliers. Take off the back metal covering from the ozonesonde. There are cell leads that are plugged into the board. These are a blue and white wires. Remove them from the board. Reinsert the intake tube into the Low/No \( O_3 \) port. Plug the sonde back into the Test Unit’s power chord. Connect the cell leads to the Test Unit by their respective colors. Run the sonde on Low/No \( O_3 \) for ten minutes. After ten minutes, record the background current \( (\mu A) \). Turn on the Lamp, pull the slide on the test unit, and run for ten minutes. After the time has passed, turn off the lamp, push in the slide and measure the time decay from 4.0 \( \mu A \) to 1.5 \( \mu A \). Run on zero air for ten minutes after the decay timing. Turn off the ozonesonde and the the Test Unit. Disconnect the cell leads from the Test Unit and short them. Replace the metal backing to the sonde. Disconnect the intake tube and store it within the sonde body.
Chapter 2 Methods

Store the sonde back within its Styrofoam box. Make sure to wrap a plastic bag or some type of bag around it for protection.

To make sure the sonde is working correctly, the numbers measured should be in range or match the numbers below. The current should have been 55-110 mA. The pressure should have read > 8 psi. Vacuum pressure should have been > 15 inHg. Background current should have been < .5 mA. Finally, the response time of decay should have been 25-75 s. If any of these numbers are off or not in range, the sonde is not ready for flight. In this case, if it is a new sonde, contact En-Sci.

The next step is 3-4 days before flight preparation. The solutions need to be replaced after the first test process. Insert the intake tube into the pump. Remove the lids of the anode and cathode tubes. Dispose of used solution in a safe place. Add 3.00 cc Cathode to the Cathode solution chamber. Replace the lid to the cathode tube, making sure the bottom tube is inserted into the Teflon post in the middle of the “clover.” Reinsert the top tube into the pump. Add 1.5 cc anode solution. Replace the lid of the anode solution back to its home. Connect the ozonesonde to the Test Unit’s power cord. Connect the cell leads to the Test Unit. Insert the intake tube to the Low/No O₃ port and run for 10 minutes. After ten minutes record the background current. Turn on the Lamp, pull the slide, and run for another ten minutes. After time has passed, turn off the Lamp and then time the decay from 4.0 µA to 1.5 µA. Run on Low/No O₃ for 10 minutes. Turn off the ozonesonde power, turn off the Test Unit, disconnect the cell leads from the Test Unit and short them. Store the sonde.

The final preparation step is a day before flight. Dispose of used solution inside a safe container. Change solutions by adding 3.0 cc cathode and 1.5 cc anode. Connect cell leads to Test Unit. Run on Low/No O₃ for 10 minutes. After ten minutes record the background current. Turn on lamp and pull the slide. Run for ten minutes. After,
2.3 Data Collection

Sections on how my data was collected follow. Both processes used telemetry but only one was saved via the internet and APRS.fi.

2.3.1 Ozonesonde Data Collection

To collect data from the ozonesonde it must be connected to the iMet Radiosonde from the port located in the back of the ozonesonde. To turn on the radiosonde, flip the switch inside to the desired frequency. These frequencies are designated for NOAA (National Oceanic and Atmospheric Administration) use so a HAM radio license is not needed. The ozonesonde must be calibrated and turned on as well to start sending out data. Proper software is required to receive this data so it saves properly. Download the SkySonde Client and the SkySonde Server from this web page, “https://www.esrl.noaa.gov/gmd/ozwv/wvap/sw.html”. These programs are for collecting and displaying radiosonde and ozonesonde telemetry in real time during a weather balloon flight. This software parses, displays, and stores wireless data from iMet radiosondes.

The first step is to get a software defined radio setup correctly to the designated recording computer. This involves many steps that I won’t include in this paper but
are found on the web page. To start recording data from the iMet radiosonde and ozonesonde, start the SkySonde Server first. This application should read if there is a software defined radio receiving transmissions from the iMet. The “PTUX” and “GPS” icons on the server should blink if the server is being updated. The second step is to start the SkySonde Client. This is where the user can name their flight, record the Radiosonde ID, and choose where to save their data. The data will save automatically once the “OK” option is pressed. The signal strength will be given in the Server application. The data and GPS information will be given in the Client. This Client will give real time graphs amongst other useful tools for recording data.

2.3.2 Trackuino Data

The Trackuino transmits data over the APRS system. The APRS community have collection sites that receive and store such data. APRS.fi is one such site. Trackuino data has been extracted from APRS.fi. This website is a way to track balloons and many other things. The Trackuino transmits at 144 MHz using the APRS Packet system. The signal is output and received and forwarded to the APRS-IS by i-gate stations run by amateur radio clubs and individuals. To extract the data from the APRS.fi network you must have an account. This account is affiliated with the individual’s call sign. Simply look up the call sign and the date where the flight took place with the data export tool.

2.3.3 Ozonesonde Data

From the iMet radiosonde, I received telemetry data from the ozonesonde. Using a software defined radio, I tuned in to the frequency of 402 MHz to receive the data. The data is then automatically saved to an Excel .csv file and updated as new
2.3 Data Collection

data comes in. The ozonesonde data I received was very limited. The signal of the iMet radiosonde was completely lost at around 6,000 meters or around 20,000 feet in altitude. This is very low in our atmosphere, and not even near close to the ozone layer. The only data I could take from the March 30th launch are in two graphs. The total ozone is measured in Dobson Units.

The Dobson Unit is the most common unit for measuring ozone concentration. One Dobson Unit is the number of molecules of ozone that would be required to create a layer of pure ozone 0.01 millimeters thick at a temperature of 0 degrees Celsius and a pressure of 1 atmosphere (the air pressure at the surface of the Earth). Expressed another way, a column of air with an ozone concentration of 1 Dobson Unit would contain about $2.69 \cdot 10^{16}$ ozone molecules for every square centimeter of area at the base of the column. Over the Earths surface, the ozone layers average thickness is about 300 Dobson Units or a layer that is 3 millimeters thick. [6]

In Figure 2.5 we see that the Ozone steadily rises until it hits a point just after 0.3 DU and becomes saturated with that value. Using python, I weeded out all the various instrumentation errors and saturation to produce a final graph for total ozone in DU. Figure 2.6 is the final product. The biggest issue is that the data is only good for even less than 1000 meters. The balloon usually goes up to about 30,000 meters. So I lost around 29,000 meters worth if ozone data. This data is just not enough to compare to anything useful.
Figure 2.5 The total ozone in the atmosphere measured in DU (Dobson Unit). This data is saturated.
2.3 Data Collection

Figure 2.6 The total ozone in the atmosphere measured in DU (Dobson Unit). This data is fixed from the saturation.
Chapter 3

Results

Each data set was fit to 2-3 different segments of either quadratic or linear models described in equations 3.1, quadratic, and 3.2, being linear. The coefficients of $a_3$ for quadratic and $a_1$ for linear show the predicted temperature at sea level. The other parameters describe how quickly the temperature is changing, analogous to how velocity and acceleration are related to position where $A$ corresponds to altitude and $T$ to temperature.

\begin{align*}
    a_1A^2 + a_2A + a_3 &= T \quad (3.1) \\
    a_2A + a_1 &= T \quad (3.2)
\end{align*}

3.1 Data Fitting

For our July 15th, July 29th, August 11th, and December 1st flights we used three separate altitude intervals to fit our models. The first interval corresponds to lowest altitude data. This is the time spent in the Troposphere. The second interval corresponds to the middle of our flight data, which is the time spent in the Tropopause and the lower Stratosphere.
Chapter 3 Results

The third interval corresponds to the altitude data found in the Stratosphere only. The data can be found in Table 3.1. During the transition from the Troposphere to the Stratosphere, and going through the Tropopause, we found that there were either linear or parabolic fits to the data. The only time we did not use three separate trends was the August 21st eclipse flight date. This set was parabolic from around 12,600 meters in the air. Below that it was only linear.

3.2 Excel and Chi Squared

The $\chi^2$ data can be found in Table 3.2. Our fits were mostly reasonable other than a few anomalies on August 21st and December 1st. Our fits were defined by the way we saw the data and what shape it matched best. There was also a lot of bad data within the Trackuino readings we had to get rid of. This data has systematic error and nothing could be done to correct it. The error was probably caused by loss of GPS lock and therefore the instrument did not transmit data. In Figure 3.5, there was a big gap of data we had to throw out because of instrument error. This affected the $\chi^2$ data in that the data was spaced.

3.3 Future Methods and Ideas

For the future, instead of using excel to plot and analyze the data, a more efficient python program could work. Other ideas could be to analyze the data side by side. We could also plot the graphs on top of each other to compare differences directly.
### 3.3 Future Methods and Ideas

Table 3.1 Balloon launch dates with fitted linear and nonlinear parameters and uncertainties to data collected.

#### July 15, 2017

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<th>Value</th>
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#### August 11, 2017

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#### August 21, 2017

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#### December 1, 2017

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Table 3.2 $\chi^2$ values for each fitted segment of the data.

July 15, 2017

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<thead>
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<th>Linear Fit: 1,000 - 14,300 m</th>
<th>Linear Fit: 14,300 - 19,100 m</th>
<th>Linear Fit: 19,100 - 30,600 m</th>
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<td>$\chi^2$</td>
<td>43.78</td>
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July 29, 2017

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<th>Non-Linear: 14,800 - 19,100 m</th>
<th>Non-Linear: 19,100 - 28,600 m</th>
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</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>220.63</td>
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August 11, 2017

<table>
<thead>
<tr>
<th></th>
<th>Linear Fit: 1,000 - 11,900 m</th>
<th>Non-Linear Fit: 11,900 - 17,000 m</th>
<th>Linear Fit: 17,000 - 27,000 m</th>
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</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>21.41</td>
<td>13.40</td>
<td>78.36</td>
</tr>
</tbody>
</table>

August 21, 2017

|                | Linear Fit: 1,000 - 12,600 m | Non-Linear Fit: 12,600 - 29,300 m |
|----------------|-----------------------------|--------------------------------|-----------------------------|
| $\chi^2$      | 480.04                      | 61.26                          |

December 1, 2017

<table>
<thead>
<tr>
<th></th>
<th>Linear Fit: 1,000 - 12000 m</th>
<th>Linear Fit: 12,000 - 15,300 m</th>
<th>Linear Fit: 15,300 - 30,300 m</th>
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</thead>
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Figure 3.1 The figure displays the data collected on July 15, 2017 and the fit to that data with temperature, $^\circ$C, on the y-axis and altitude, m, on the x-axis.
3.3 Future Methods and Ideas

Figure 3.2 The figure displays the data collected on July 29, 2017 and the fit to that data with temperature, $^\circ C$, on the y-axis and altitude, m, on the x-axis.

Figure 3.3 The figure displays the data collected on August 11, 2017 and the fit to that data with temperature, $^\circ C$, on the y-axis and altitude, m, on the x-axis.
Figure 3.4 The figure displays the data collected during the Solar Eclipse on August 21, 2017 and the fit to that data with temperature, °C, on the y-axis and altitude, m, on the x-axis.

Figure 3.5 The figure displays the data collected on December 1, 2017 and the fit to that data with temperature, °C, on the y-axis and altitude, m, on the x-axis.
Chapter 4

Conclusion

While being a key factor of setting up a balloon project, having a tracker is a must. We were interested in having the most reliable tracker. The Trackuino has the most power output throughout the whole experiment, allowing us to collect data for its location and a number of other things such as temperature. This method of tracking an object is very useful, especially when we send our Trackuino up into the atmosphere where it will have ideal range and be able to reach further away repeaters. We can accurately track an object anywhere as long as it has a line of sight with a radio repeater.

Our instrument, the Trackuino, wasn’t the most accurate at measuring temperature but it has much more to offer in terms of measuring. If we had more flights to work with this would increase the accuracy of our model. Especially if we had flights in different seasons, we could see how the atmosphere reacts with them. We only worked with the summer months and one December flight run.

Our secondary purpose was to compare our “normal” flight data to the flight data retrieved on August 21st, the day of the solar eclipse. There wasn’t enough data points to see the difference between flights. If we had more data points we could maybe see
more of a difference, but sadly we do not. At approximately 40,000 feet, or around 12,000 meters, was when the solar eclipse occurred during the flight. According to the temperature readings all was normal and fit to our other data. Around this area is when the atmosphere turns from the Troposphere to the Tropopause to the Stratosphere. The current model for the transition is a straight line. This means that the temperature is constant around this area of the atmosphere. This is around where the ozone layer of the atmosphere is. The temperature at the transition point, where the balloon was located during the total eclipse, was least affected thus preventing us from retrieving any useful data.

4.1 Comparing Temperature and Ozone Data to the U.S. Standard Atmosphere

The Trackuino data is very comparable. The first three phases of temperature change are shown. The rise in temperature due to the ozone layer is also shown. As for ozone, there is not much data to compare. The profile of data I received was not sufficient enough to comprehensively compare to the U.S. standard atmosphere’s model for ozone.

4.2 Future Projects

Future projects could include launching a balloon monthly and taking the average data as to show whether the change in seasons directly affect the atmosphere or not. Other projects could include making an SD card compatible with the radiosonde and ozonesonde and cutting telemetry out of the equation, saving all the data whether or not we have signal strength.
Bibliography


