How can a weather balloon launch help engage students in authentic learning?

What is the atmosphere?

How do we study it?

Felix Baumgartner’s stratospheric jump

1:30 summary montage https://www.youtube.com/watch?v=FHtvDA0W34I

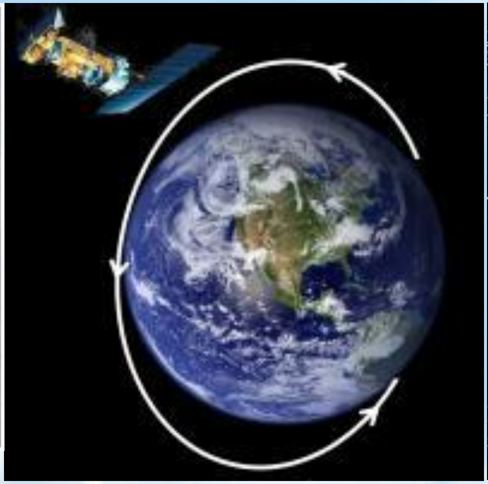
How do we study conditions in the atmosphere?

Animation to show POES v. GOES: http://spaceplace.nasa.gov/geo-orbits/

Weather balloons

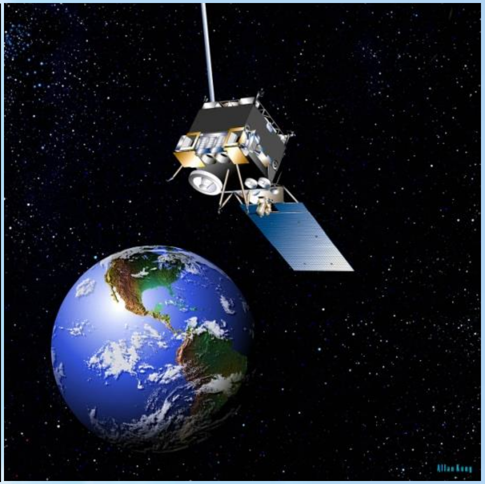
Unpiloted NASA weather drone

Image accessed on 9.30.13 from: http://weatherlabs.planet-science.com/weather-forecasts/where-do-forecasters-get-data.aspx



POES: polar-orbiting Operational Environmental Satellite

Accessed on 9.30.13 from: http://www.automatedsciences.com/intro/intro.shtml



GOES: geostationary Operational Environmental Satellite

Accessed on 9.30.13 from: http://4.bp.blogspot.com/_ddqtkOiADuo/TESByWXE06I/AAAAAAAAFAU/GeCaNxjoifY/s1600/GOES-13+is+America%E2%80%99s+New+GOES-EAST+Satellite.jpeg

Weather observations

Accessed on 9.30.13 from: http://www.southcoasttoday.com/apps/pbcs.dll/article?AID=/20070228/NEWS/702280334&cid=sitesearch

Human free fall jumps

Accessed on 9.30.13 from: http://www.extremetech.com/extreme/137867-the-best-photos-and-videos-of-felix-baumgartners-record-breaking-skydive

Doppler RADAR

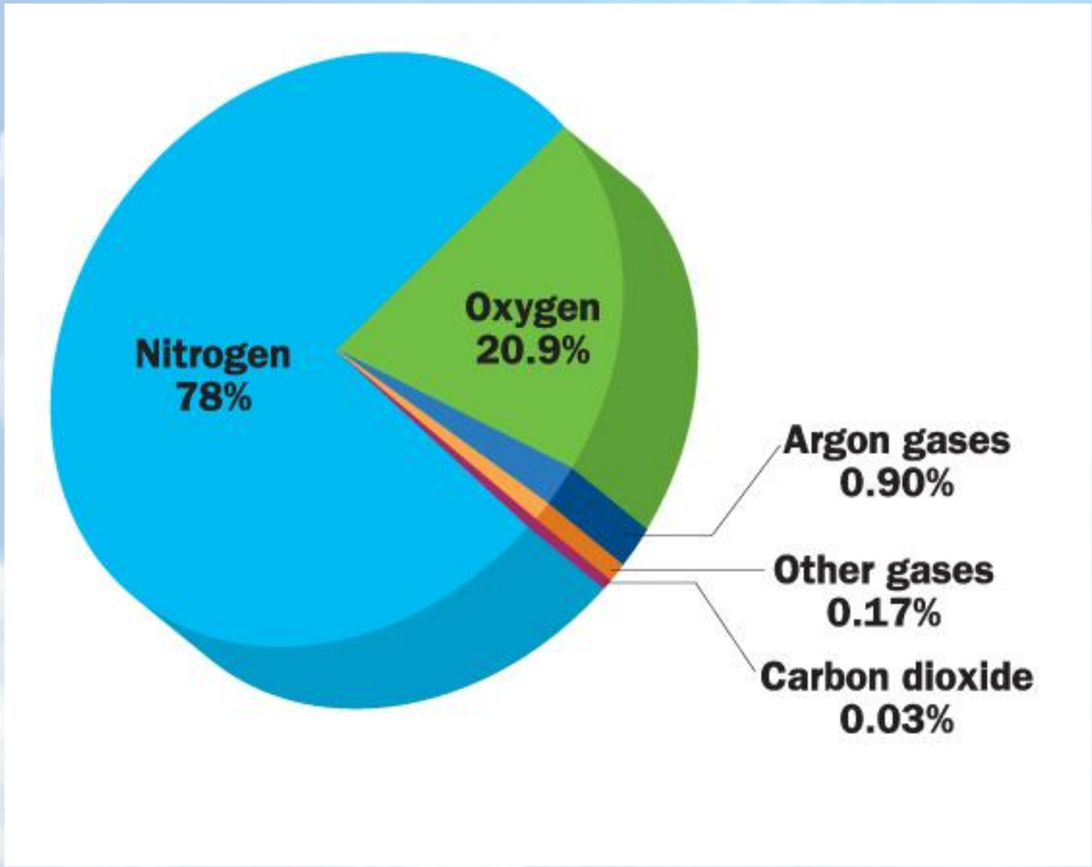
Image accessed on 9.30.13 from: http://www.uvm.edu/~swac/?Page=photogallery.html

Goals

- how atmospheric properties vary with altitude
- how radiosondes and SWAC Sondes work
- explore weather balloon launch data
- logistics of a weather balloon launch
- curriculum connections

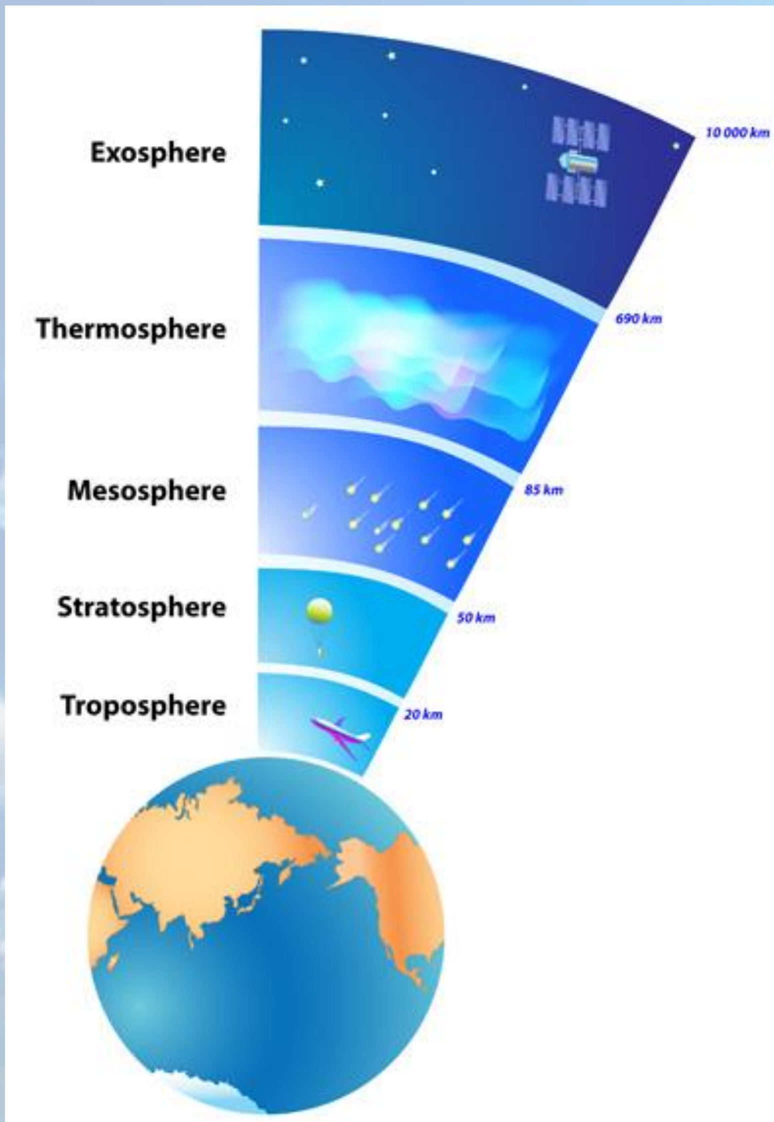
What is the atmosphere?

- envelope of gases surrounding a planet



Graph image accessed on 3.16.2014 from: http://pattiisaacs.files.wordpress.com/2011/12/air-composition-pie-chart2.jpg
Sky image accessed on 3.16.2014 from: http://climate.nasa.gov/system/news_items/main_images/blue_sky_clouds_538px.jpg

How is the atmosphere structured?



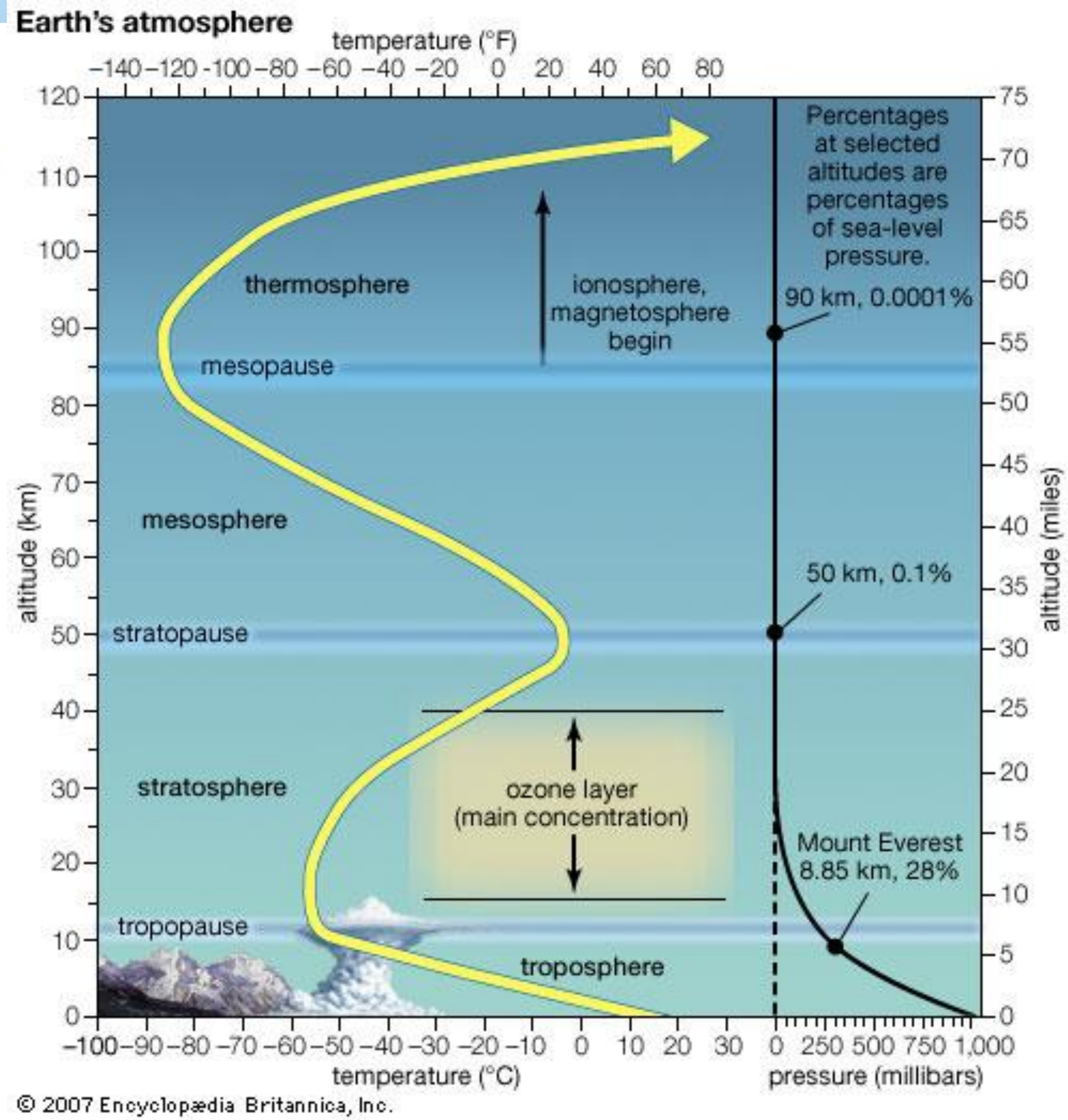


Image accessed on 3.13.14 from: http://ete.cet.edu/gcc/style/images/uploads/student%20pages/earth-atmosphere-layers.jpg

Image accessed on 3.13.14 from: http://media.web.britannica.com/eb-media/56/97256-004-E3540AD9.jpg

What is a Radiosonde?

radio – sends a radio signal   sonde – device to collect physical data

- **Balloon carries meteorological instruments aloft**

- ***Temperature*, *moisture*, *pressure*, and *wind* measured at many levels**

- **Provides *snapshot of these variables in the vertical***

- **This information allows meteorologists to *diagnose the atmosphere* in the vertical**

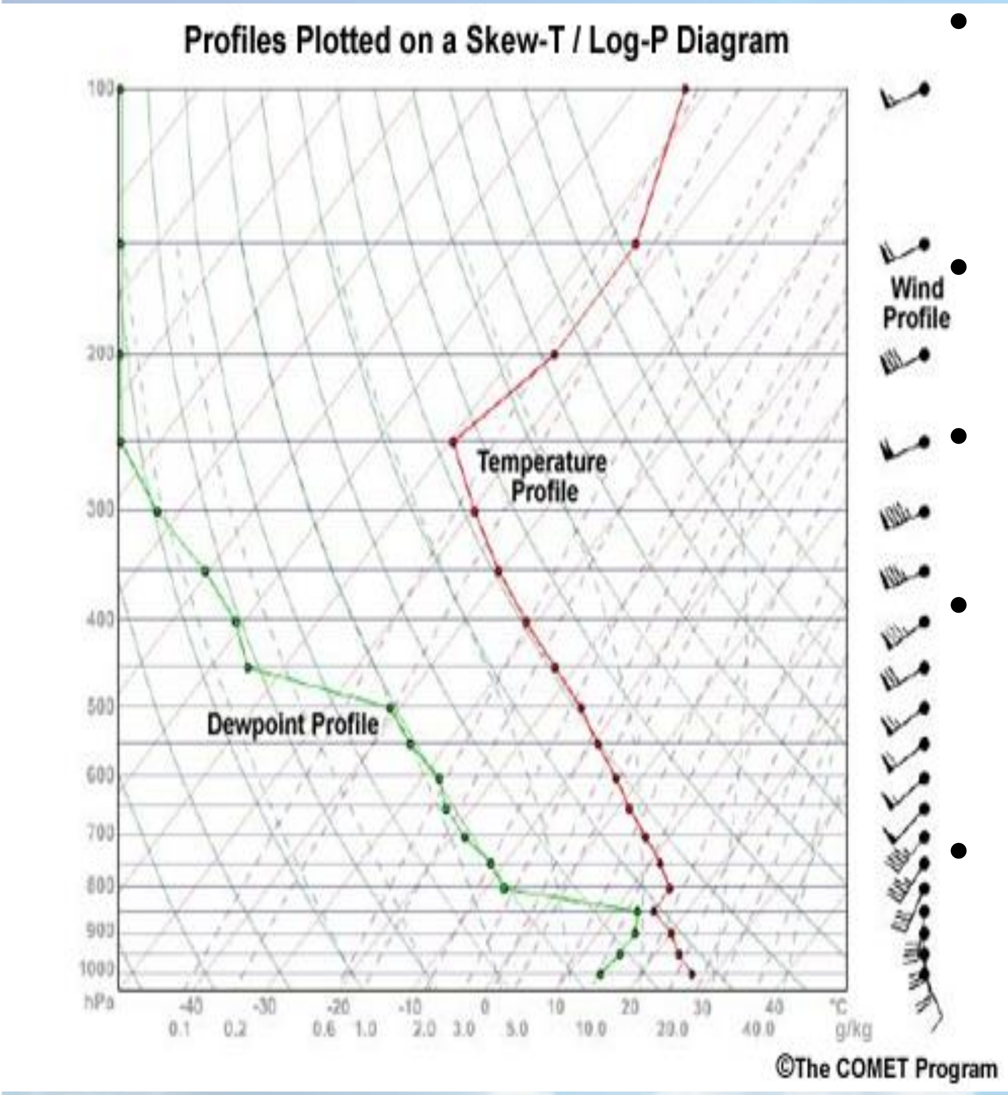
Why are these measurements important?

- ***These observations*** ***<u>allow us to diagnose the atmosphere</u>*** similar to the snapshot that blood pressure measurements provide the doctor

- When coupled with surface weather reports and satellite data, ***<u>we get a 3 dimensional view</u>*** ***(horizontal, vertical and time) of atmosphere***

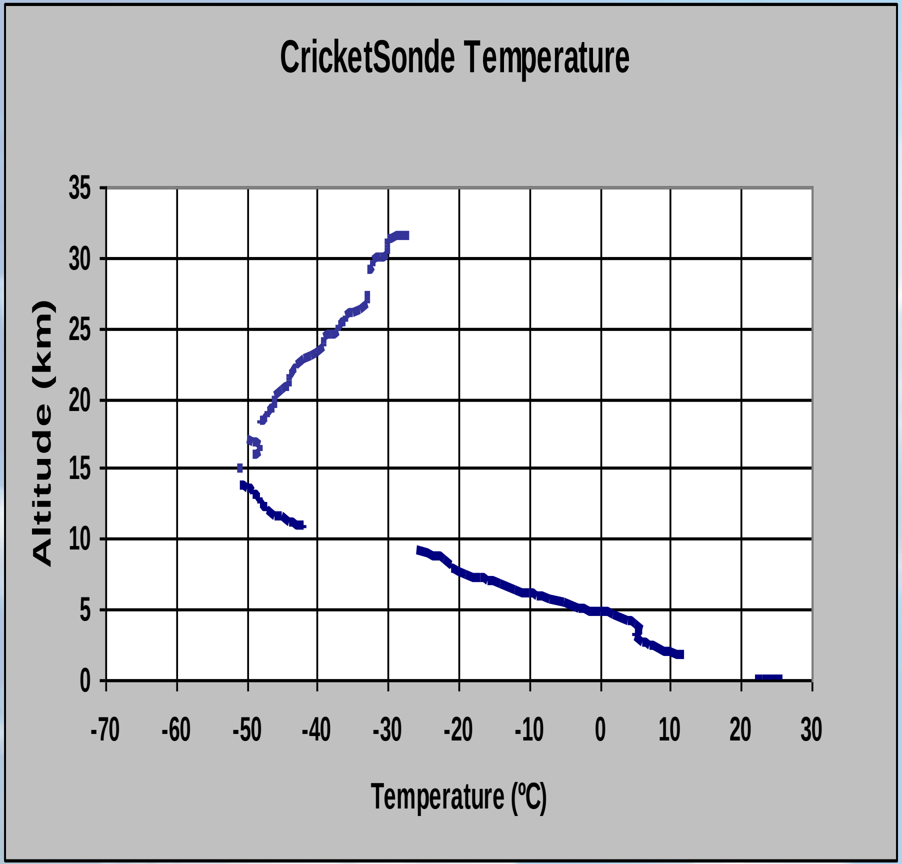
- These measurements provide clues assisting the meteorologist in ***<u>understanding and anticipating motion in the atmosphere</u>***

What does a vertical plot look like?



- ***Temperature and Dewpoint (moisture) are plotted at appropriate pressure levels***
- Temperature values are connected with RED line
- Dewpoint values are connected with GREEN line.
- The closer together the temperature and dew point, the more moist the air is.
- ***Where the lines are close, clouds are likely***

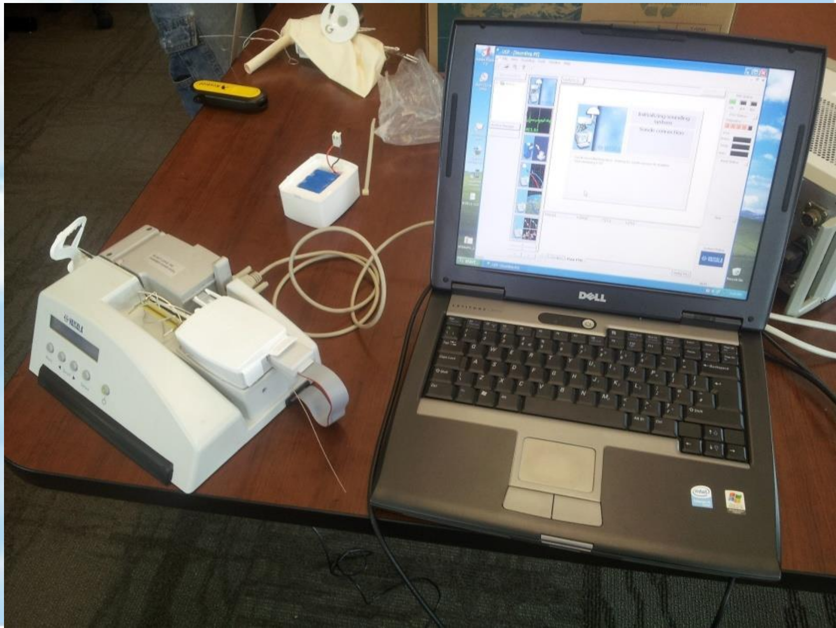
Note relationship between temperature and altitude



- Temperature decreases with altitude in lower portion of atmosphere (Troposphere)
- Temperature increases with altitude in upper portion of atmosphere (Stratosphere)

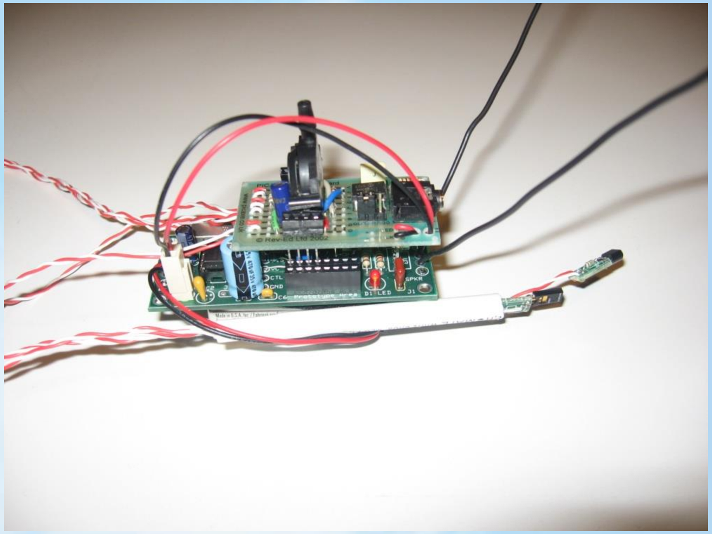
NWS Radiosonde System

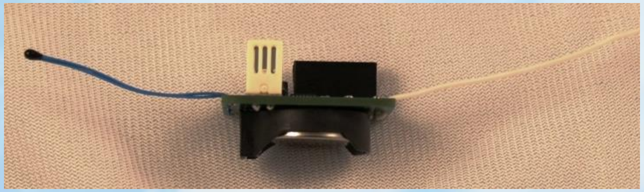
- **Atmospheric Measurements**
- Temperature, Pressure, Humidity, Wind (indirectly)
- **Air-borne Payload System - $250**
- Weather balloon, Helium, Parachute, Radiosonde (403 MHz or 1.6 GHz)
- **Ground Receiving Station - >$2000 (without computer)**
- 5-Element Yagi antenna and tripod, UHF radio receiver and modem, Computer and data collection software
- **Advantages**
- Robust data , Automatic data collection, Stratosphere and troposphere measurements (30 km altitude)
- **Disadvantages**
- High system cost , Apparently available only for government and research use , Encoded data requires expensive computer software to decipher



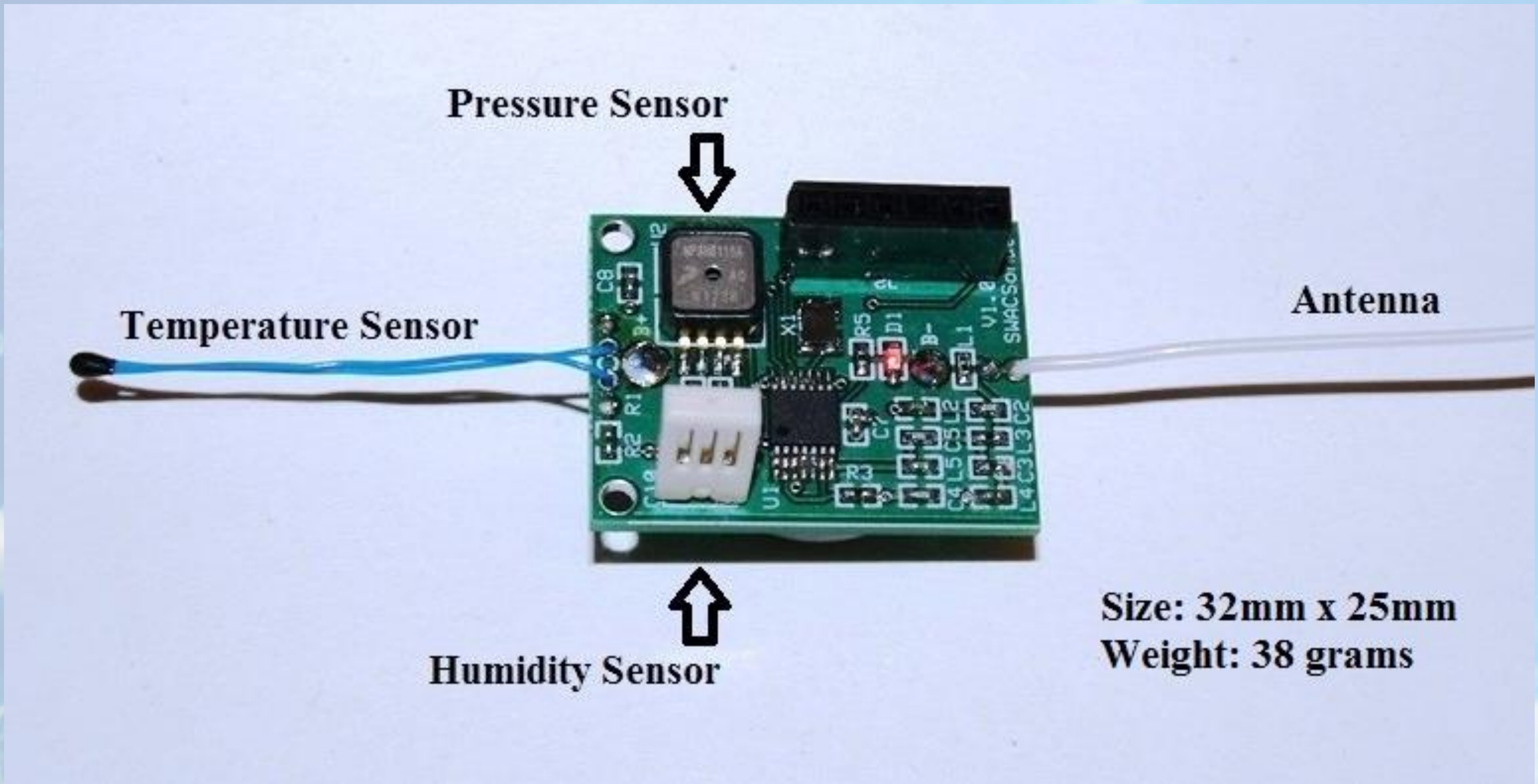
UVM SWAC Sonde

- **Air-borne Payload System: - $100**
- Party balloon (Helium-filled), Model rocket parachute, UVM CricketSonde (434 MHz) housed in simple enclosure
- **Ground Receiving Station - $230**
- 3-Element Yagi Antenna, UHF Radio Receiver, Pen and Paper
- **Advantages**
- Simple data collection method provides, real-time results, Launch most any place or time, Low system cost, Troposphere measurements (up to 10 km using party balloon), Stratosphere measurements (up to 30 km using weather balloon)
- **Disadvantages**
- May require technician-class amateur (Ham) radio license to operate





SWAC Sonde


Pressure Sensor
Temperature Sensor
Antenna
Humidity Sensor
Size: 32mm x 25mm
Weight: 38 grams

How does a SWAC Sonde communicate temperature?

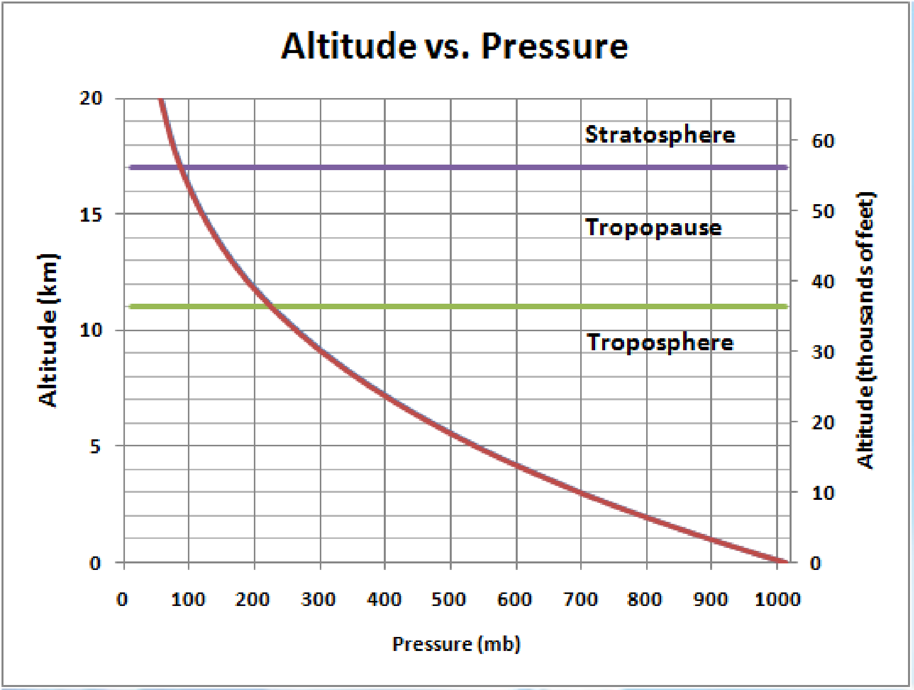
(how to convert)	→ (°F – 32) x 5/9 = °C → °C + 273 = K °F = (°C x 9/5) + 32 ← °C = K - 273 ←		
	Temperature (°F)	Temperature (°C)	Temperature (K)
melting point of water	32	0	273
human body temperature	98.6	37	310
boiling point of water	212	100	373

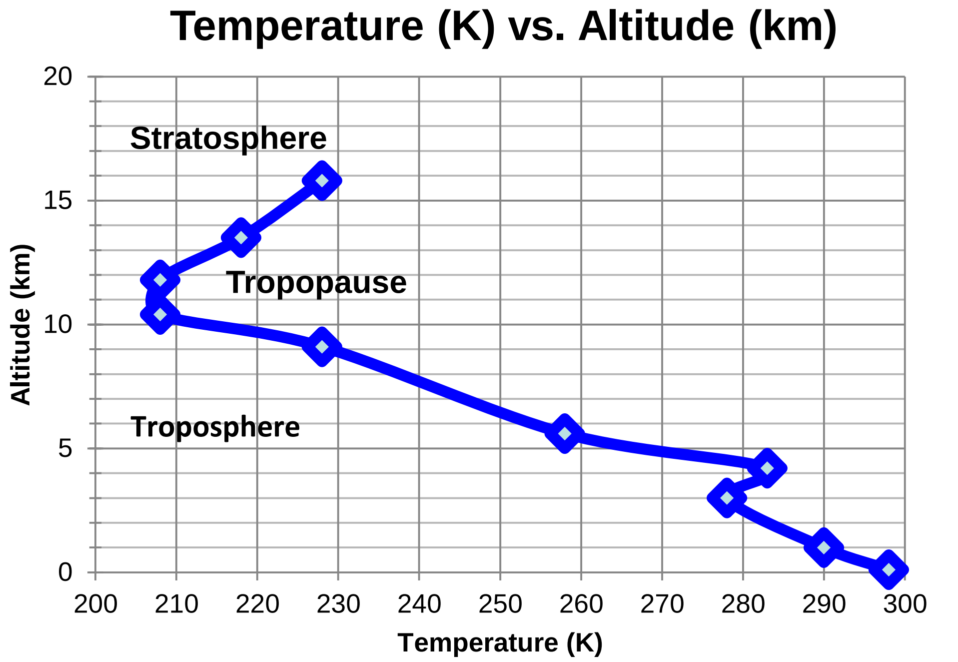
CricketSonde practice

Conditions	Sample #	Pressure (mb) ____ ____ ____ ____	Temperature (K) ____ ____ ____	Humidity (%) ____ ____

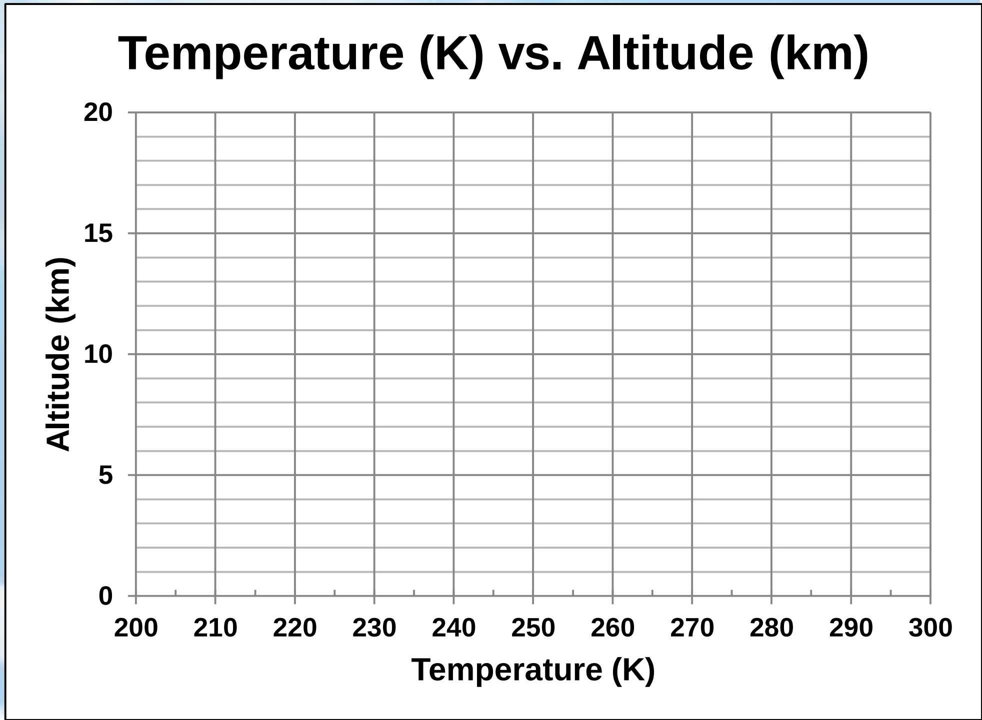
Flight data (condensed) practice

Sample #	Altitude (km)	Pressure (mb) ____ ____ ____ ____	Temperature (K) ____ ____ ____
1	0.110	1000	2 9 8
2	1.0	900	2 9 __
3	3.0	700	2 __ __
4	4.2	600	__ __ __
5	5.6	500	__ __ __
6	9.1	300	__ __ __
7	10.4	250	__ __ __
8	11.8	200	__ __ __
9	__ __. __	150	__ __ __
10	__ __. __	100	__ __ __





To convert pressure to altitude, students can interpolate using the graph above or they can use an online calculator such as the one on NOAA: http://www.srh.noaa.gov/epz/?n=wxcalc_pressurealtitude



Data exploration

- Using data from today's forecasted sounding, you will:

<u>In Excel</u>:

1. Graph sounding (temperature and altitude) data

2 Determine the altitude of the bottom of the tropopause

3. Calculate ascent rate

    Measure the circumference of a party balloon

    Measure the mass of the payload

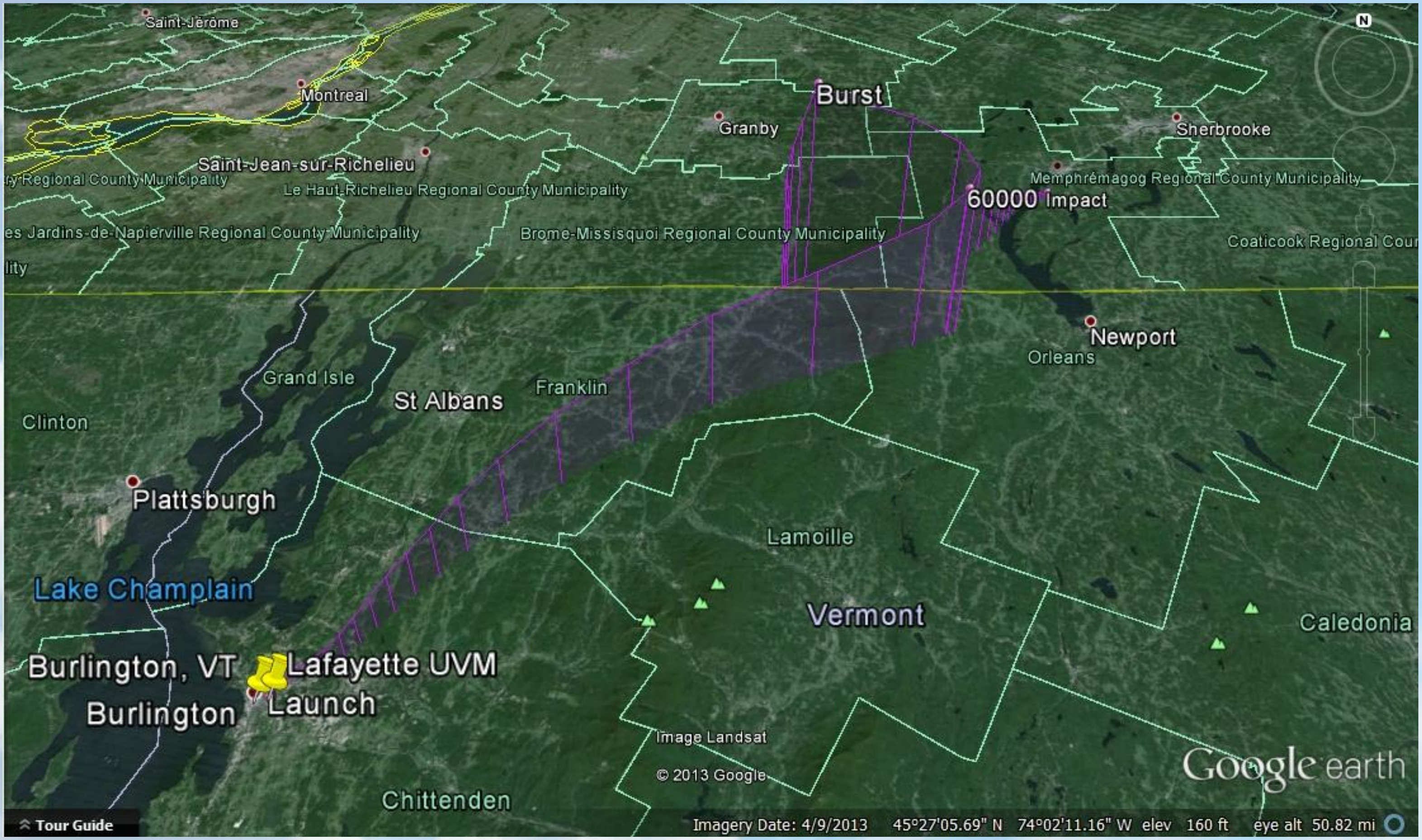
4. Calculate flight time to reach tropopause

<u>In Google Earth:</u>

5. Map where the balloon would travel if launched today from UVM and your school

Discussion of data exploration

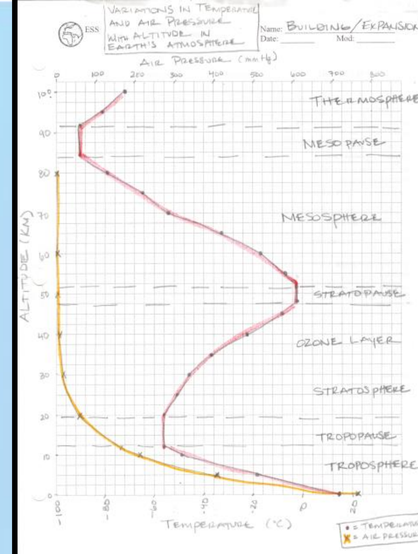
- Where would your balloon end up?

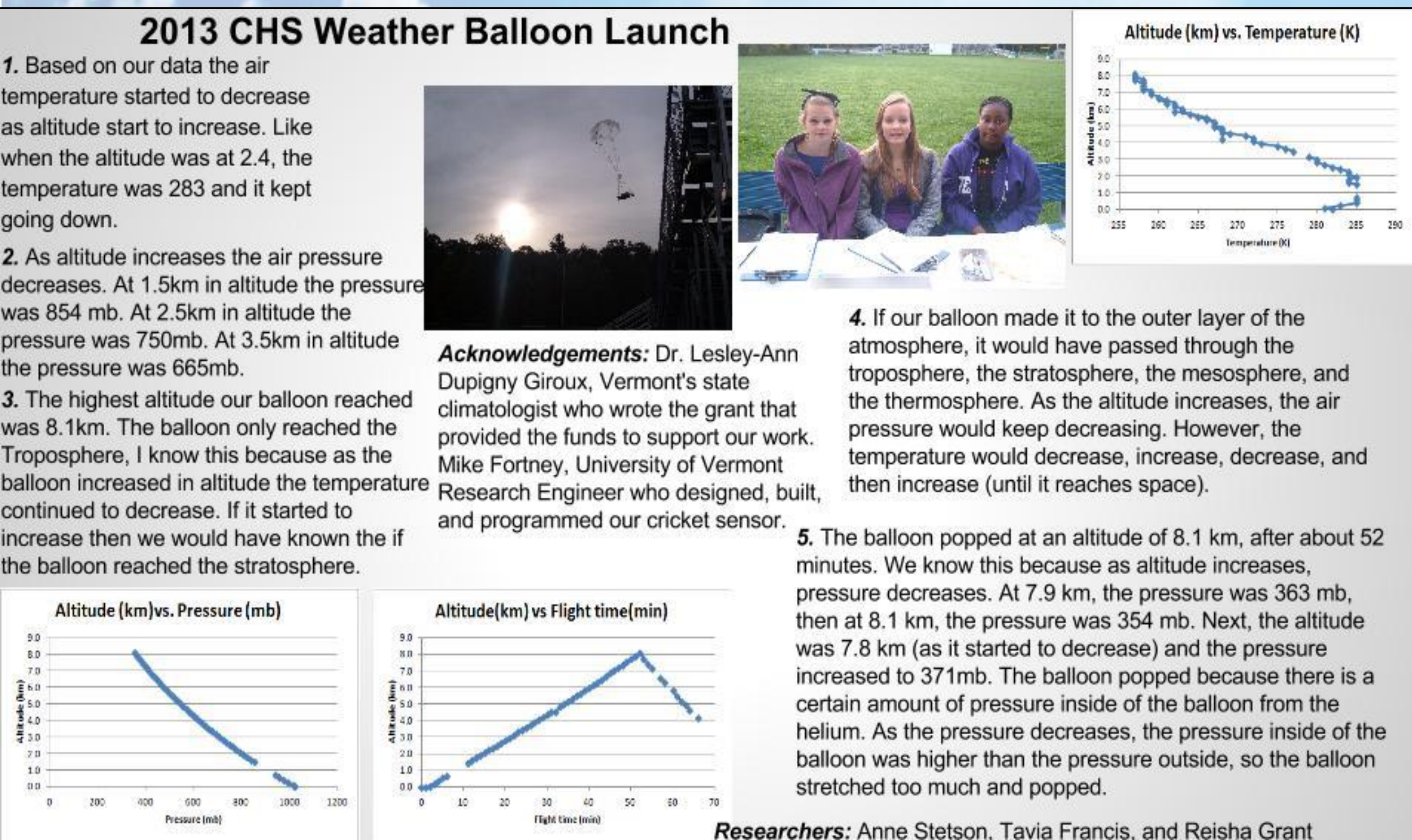


Curriculum connections

Colchester H.S. example

- Studied structure, function, composition of atmosphere
- Design challenge (payload, parachute, & “if found” letter)
- Data collection
- Data analysis & communication through formal scientific poster





2013 CHS Weather Balloon Launch

1. Based on our data the air temperature started to decrease as altitude start to increase. Like when the altitude was at 2.4, the temperature was 283 and it kept going down.

2. As altitude increases the air pressure decreases. At 1.5km in altitude the pressure was 854 mb. At 2.5km in altitude the pressure was 750mb. At 3.5km in altitude the pressure was 665mb.

3. The highest altitude our balloon reached was 8.1km. The balloon only reached the Troposphere, I know this because as the balloon increased in altitude the temperature continued to decrease. If it started to increase then we would have known the if the balloon reached the stratosphere.

Altitude (km) vs. Temperature (K)

4. If our balloon made it to the outer layer of the atmosphere, it would have passed through the troposphere, the stratosphere, the mesosphere, and the thermosphere. As the altitude increases, the air pressure would keep decreasing. However, the temperature would decrease, increase, decrease, and then increase (until it reaches space).

Acknowledgements: Dr. Lesley-Ann Dupigny Giroux, Vermont's state climatologist who wrote the grant that provided the funds to support our work. Mike Fortney, University of Vermont Research Engineer who designed, built, and programmed our cricket sensor.

5. The balloon popped at an altitude of 8.1 km, after about 52 minutes. We know this because as altitude increases, pressure decreases. At 7.9 km, the pressure was 363 mb, then at 8.1 km, the pressure was 354 mb. Next, the altitude was 7.8 km (as it started to decrease) and the pressure increased to 371mb. The balloon popped because there is a certain amount of pressure inside of the balloon from the helium. As the pressure decreases, the pressure inside of the balloon was higher than the pressure outside, so the balloon stretched too much and popped.

Altitude (km)vs. Pressure (mb)

Altitude(km) vs Flight time(min)

Researchers: Anne Stetson, Tavia Francis, and Reisha Grant

Questions and Closing

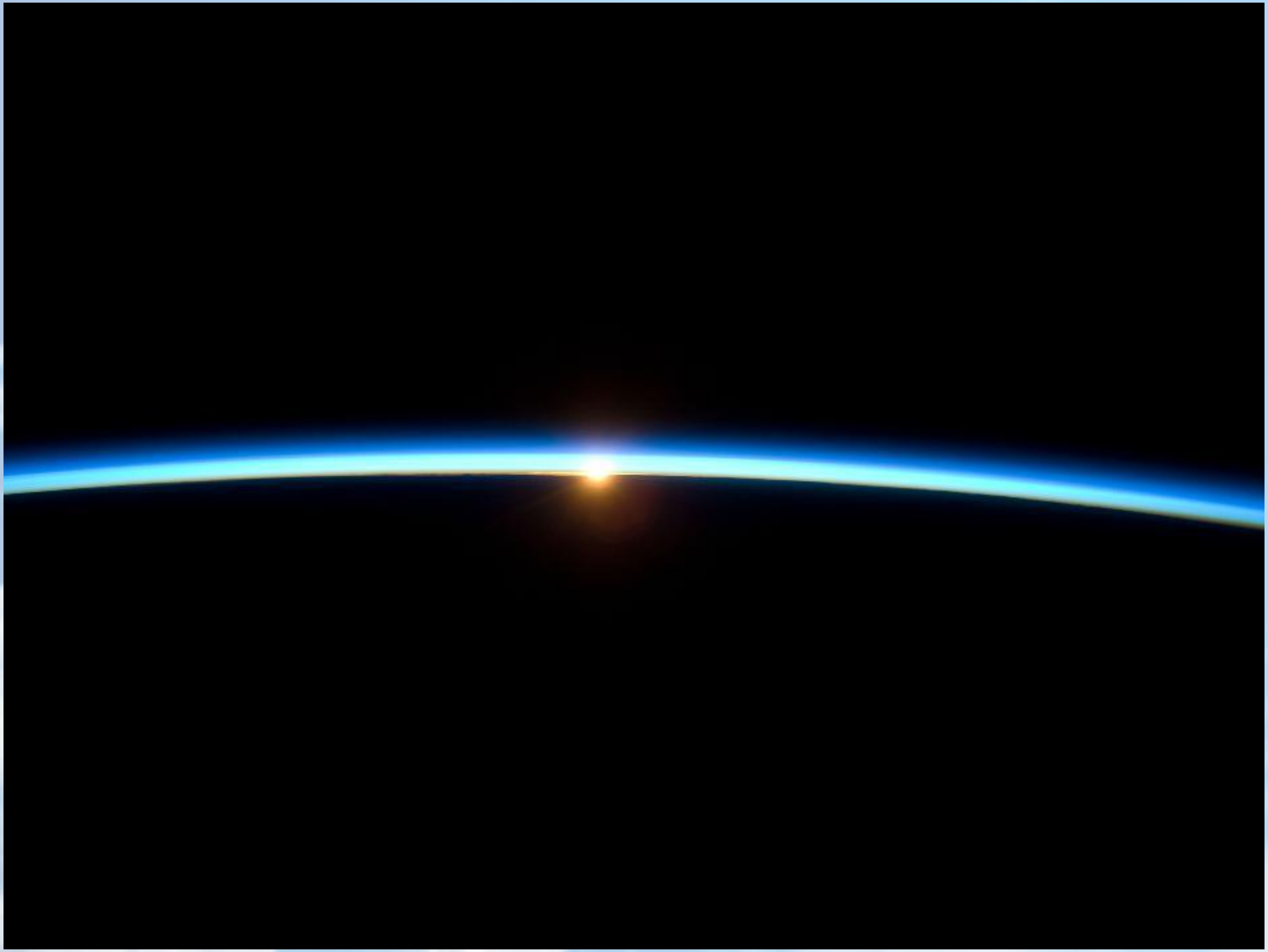


Image accessed on 3.16.2014 from: http://www.nasa.gov/images/content/407252main_image_1529_946-710.jpg