LaACES Student Ballooning Course

Student Payload Possibilities 2020

Ballooning Unit

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Balloon Payload Requirements

- Limited to about 500 grams weight
- Roughly a polygonal prism with 15 cm to 20 cm long sides
- Mechanical structure constructed from ¾” polystyrene foam
- Vehicle interface is a pair of strings, separated by ~17 cm, that pass through the payload unbroken and secured with spring clips.

Payload mechanical interface

- Need to conduct some kind of science or technology experiment
- Designed, built, tested and shown to be fully “space worthy” by May 2020.
  - You will need to successfully complete three major reviews of your progress.
- 48 hours after launch you will need to have calibrated science results from your flight and present your results to an audience of professional scientists and engineers.

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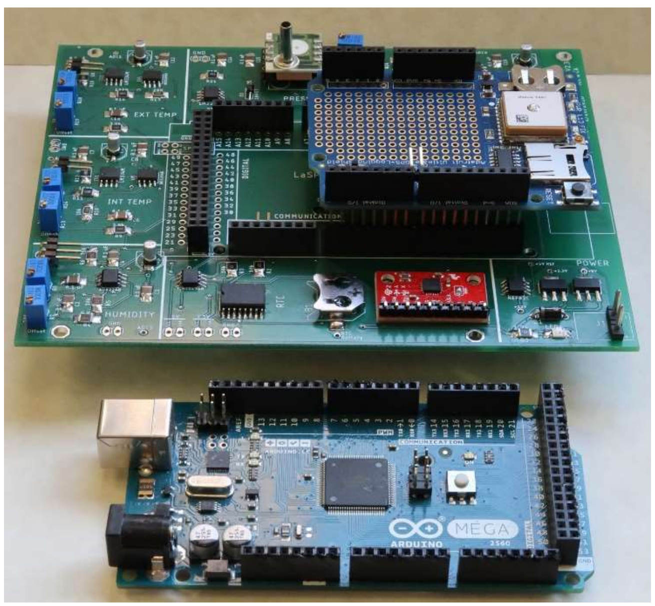
LaACES MegaSat Core

- The core of your payload will be the LaACES MegaSat that includes
  - Two temperature sensors, one humidity sensor, one pressure sensor, 3-axis accelerometer, 3-axis gyroscope, and a real-time clock with backup battery
- Payload controller will be the Arduino Mega.
- Will have the Adafruit Ultimate GPS Logger shield for GPS data throughout the flight and recording your data on a SD card.



LaACES MegaSat payload stack

- You can use the prototype area on the Adafruit GPS shield or a separate board to interface with other sensors.
- You will begin construction of your MegaSat shield in a few weeks
- Need to include in your planning
  - The components that will be part of your payload
  - Time needed to construct the MegaSat shield
  - How you will interface your sensors to the Mega

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Need to begin thinking now!

- Given the constraints, you need to think about and address issues throughout the academic year
- Here we discuss some example payloads
  - Either previously developed and flown or
  - Should be feasible to develop and fly within the limitations of this program
  - **Your team needs to choose one of these examples!**
- Your team will have two weeks to develop your Pre-PDR
  - Research and write the scientific background for your payload
  - Determine your mission goal, objectives, and requirements
  - Establish a general schedule for payload development
- **You will write a complete a defense (i.e. the FRR) of your payload proposal by the end of this semester.**

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Some possibilities

1. Radiation Intensity as a function of altitude
2. Measure intensity of UV bands as function of altitude to deduce properties of ozone layer
3. Directly measure concentration of O_3, NO_x, CO_x gases as a function of altitude using solid state sensors
4. Develop a system to measure air flow (e.g. hot wire anemometer) at high altitudes (i.e. very low pressure).
5. Investigate methods to optimize atmospheric temperature measurements
6. Investigate thermal flow and conductivity of boundary layer around payload
7. Develop an inertial sensing system which will provide sub-minute of arc orientation knowledge

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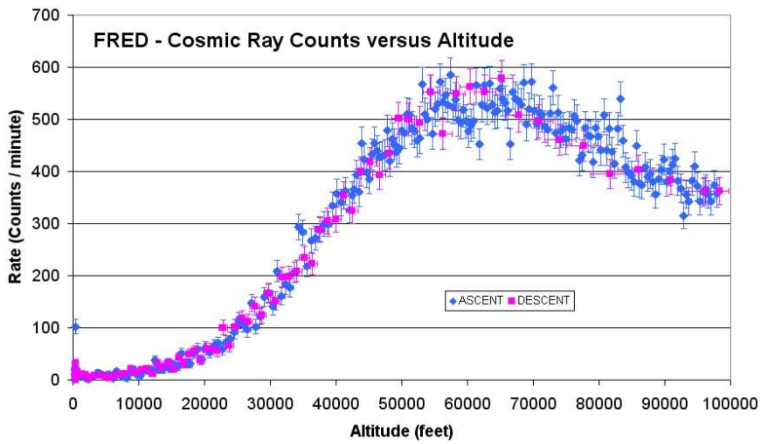
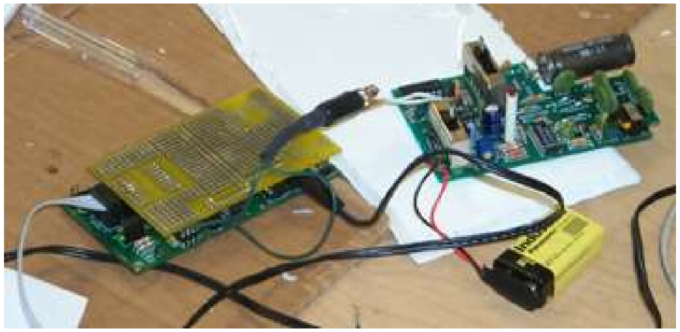
Radiation Intensity vs Altitude



- Cosmic rays are high energy nuclei that originate outside our solar system.
- CR interact in Earth's atmosphere producing a shower of particles
- The intensity of this radiation varies with altitude
- This payload would determine the radiation flux as a function of altitude on ascent and descent
- Two sensors to implement and compare 1) Geiger-Muller tube, 2) Scintillator and solid state PM



- Determine a rough energy spectrum by comparing count rates with different thresholds.

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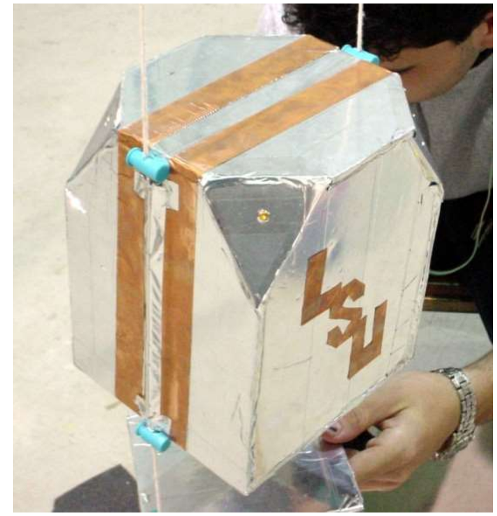
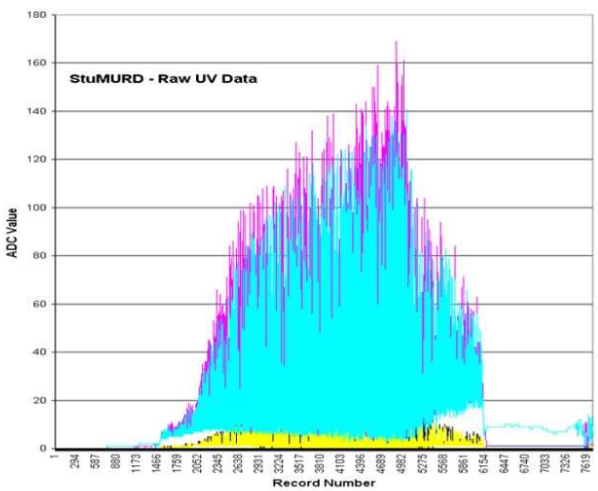
Intensity of UV versus Altitude



- UV is absorbed by ozone in the upper atmosphere
  - Surprisingly there are few (none?) published measurements of UV intensity in the stratosphere.
  - This effort has the potential of generating a journal publication with the team as authors!
- Payload would measure the UV intensity as a function of altitude and infer the vertical distribution of ozone
- One or more sensors (or the appropriate wavelength sensitivity) would monitor UV from the Sun.



- The signal from the sensor would need to be conditioned and converted to a digital number by an ADC
- You will need to take into account rotation of the balloon craft
- Calibrations of sensor and ADC will be needed to determine flux

Measure Atmospheric Components

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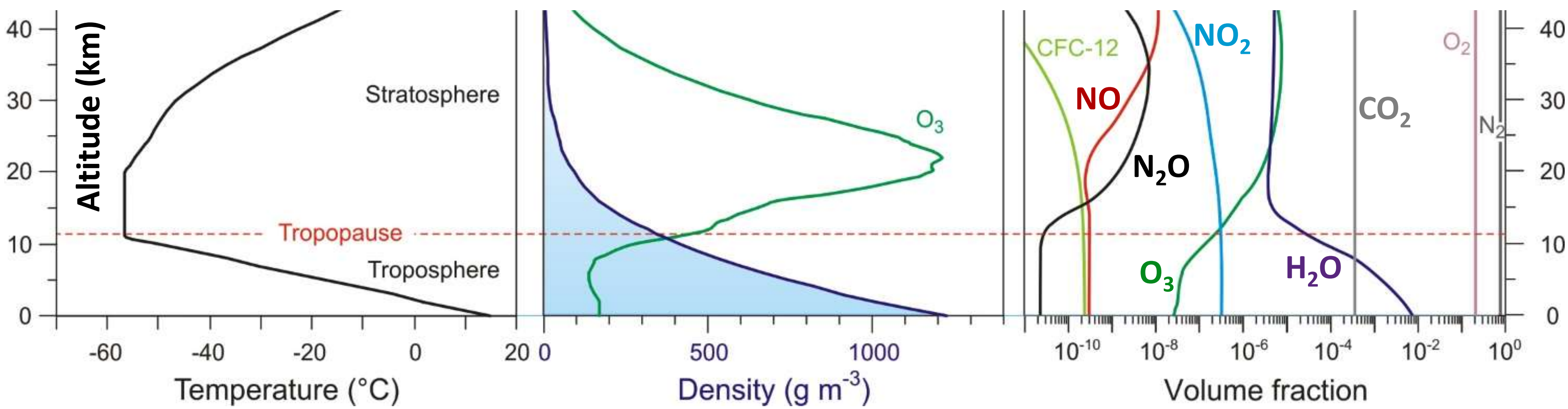
- The gas composition of the atmosphere changes as a function of altitude
- The increase in temperature above the Tropopause is related to the ozone layer
- This payload would measure trace gases using solid state sensors
- Correlate stratospheric temperature with ozone concentration

- The aerosol particle density also changes as a function of altitude
- Determine how to measure aerosol characteristics (density, size distribution) as a function of altitude



Generalic, Eni. "Troposphere." *Croatian-English Chemistry Dictionary & Glossary*. 20 Oct. 2018. KTF-Split. 9 Jan. 2020. <https://glossary.periodni.com>.

Air Flow Sensing

- Payload would measure the air flow or ‘wind speed’ as a function of altitude using a hot-wire anemometer
- Investigate various techniques used to build hot-wire anemometers
- Investigate methods to calibrate a hot-wire anemometer sensitive enough to measure small ‘wind speeds’
- Determine the wind speed and the air pressure and use them to calculate the air mass flow rate
- Payload can use the upward movement of the payload to generate the wind across the anemometer

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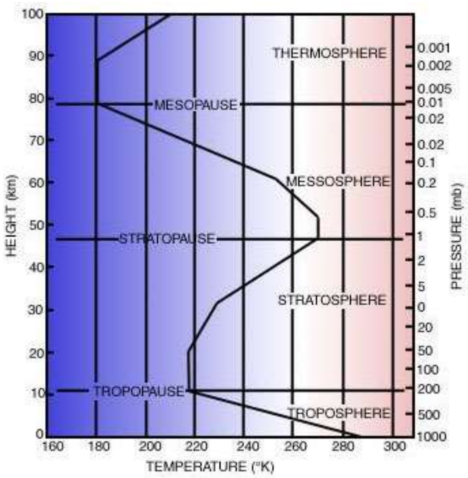
Accurate Atmosphere Temperature



- The temperature and pressure of the atmosphere varies as a function of altitude.
- Temperature initially decreases with increasing altitude, then increases as UV is absorbed in the atmosphere.
- Pressure decreases in an exponential manner
- Many factors influence the accuracy of atmospheric temperature including the sensor color, air flow around the sensor, where the sensor is placed.
- This payload would need to investigate and quantify the different influences, develop a method for accurately measuring the atmospheric temperature, and quantify the measurement uncertainty.
- Measurements should be compared with NOAA soundings.

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Thermal Investigations

- Investigate thermal flow & conductivity of boundary layer around payload
- Temperature sensors on box interior, interior surface, exterior surface, 5 cm boom and 10 cm boom
- Determine heat flow and the payload effect on measuring the temperature of the atmosphere.
- Optimizing thermal shields for temperature sensors
- Temperature sensors on 10 cm booms with white, black, checkered and silver shields
- Measure and model the "atmospheric temperature" measured by the four sensors

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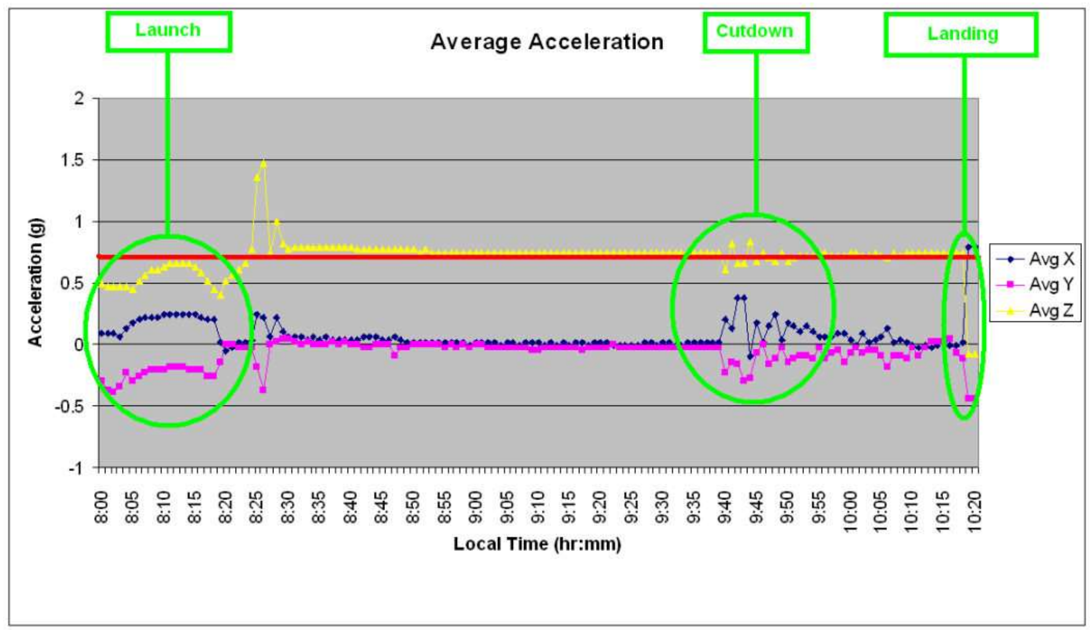
Minute of Arc Inertial System

- Develop an inertial attitude sensing system that would be accurate to less than one minute of arc
- Use to investigate the rotation and turbulence of the payload during flight
- Use some combination of magnetometer compass, tilt sensors, fiber-optic gyroscopes, accelerometers and a sun sensor
- Develop system that would determine payload attitude to about one arc-minute
- Correlate observed turbulence with atmosphere layers



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Short term schedule

- On Thursday, January 16, 2020 your team will provide a very short presentation (3 to 5 slides) on your payload choice and how you plan to proceed with your payload development
- On 1/28/20 your team will need to provide the more extensive Pre-PDR presentation that describes your mission goal, science / technical background, objectives and requirements.
- On 2/11/20 your team will provide the full PDR presentation and on 2/14/20 the complete PDR document will be due
- Keep in mind that you will be working on your PDR presentations and document while still proceeding with the MegaSat and other LaACES activities.

Do not think that you can do all this overnight!