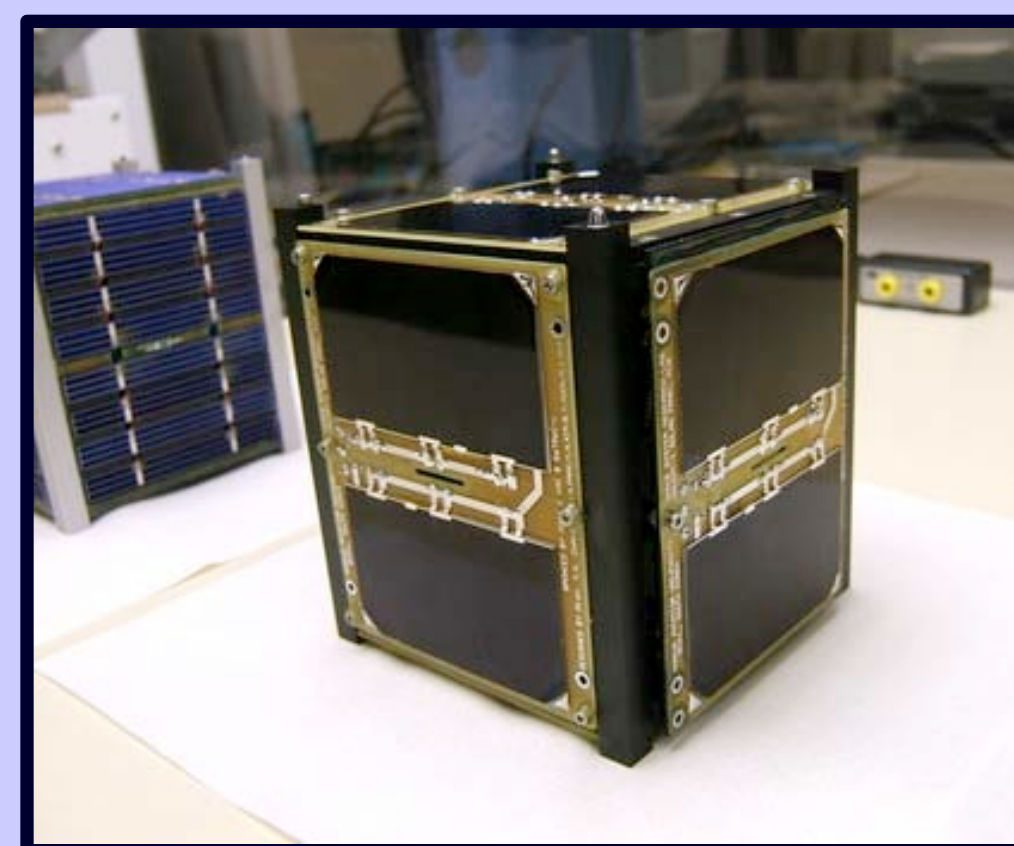


Cube Sats

- 10 cm x 10 cm x 10 cm cubes
- Mass \leq 1 kg
- Picosatellites
- Follow standards from California Polytechnique University and Stanford University
- Launch cost \approx \$40,000
- Multiple CubeSats launched at a time

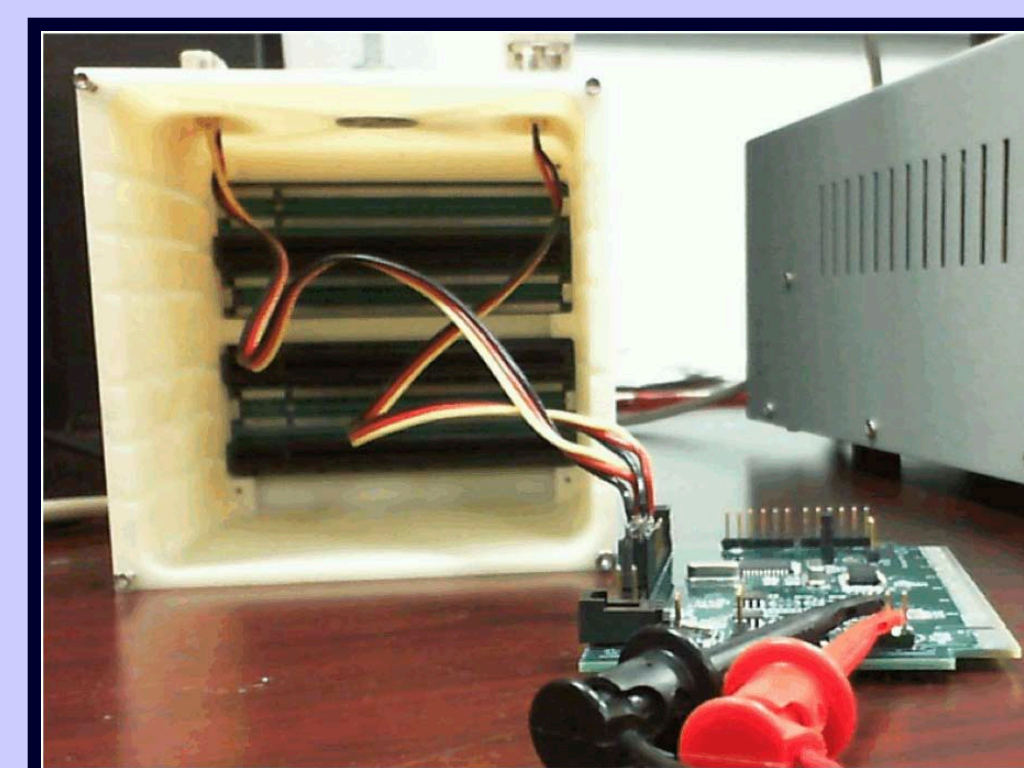


Example of a CubeSat:
Image from CubeSat *In the News*

ABSplus Balloon Satellite

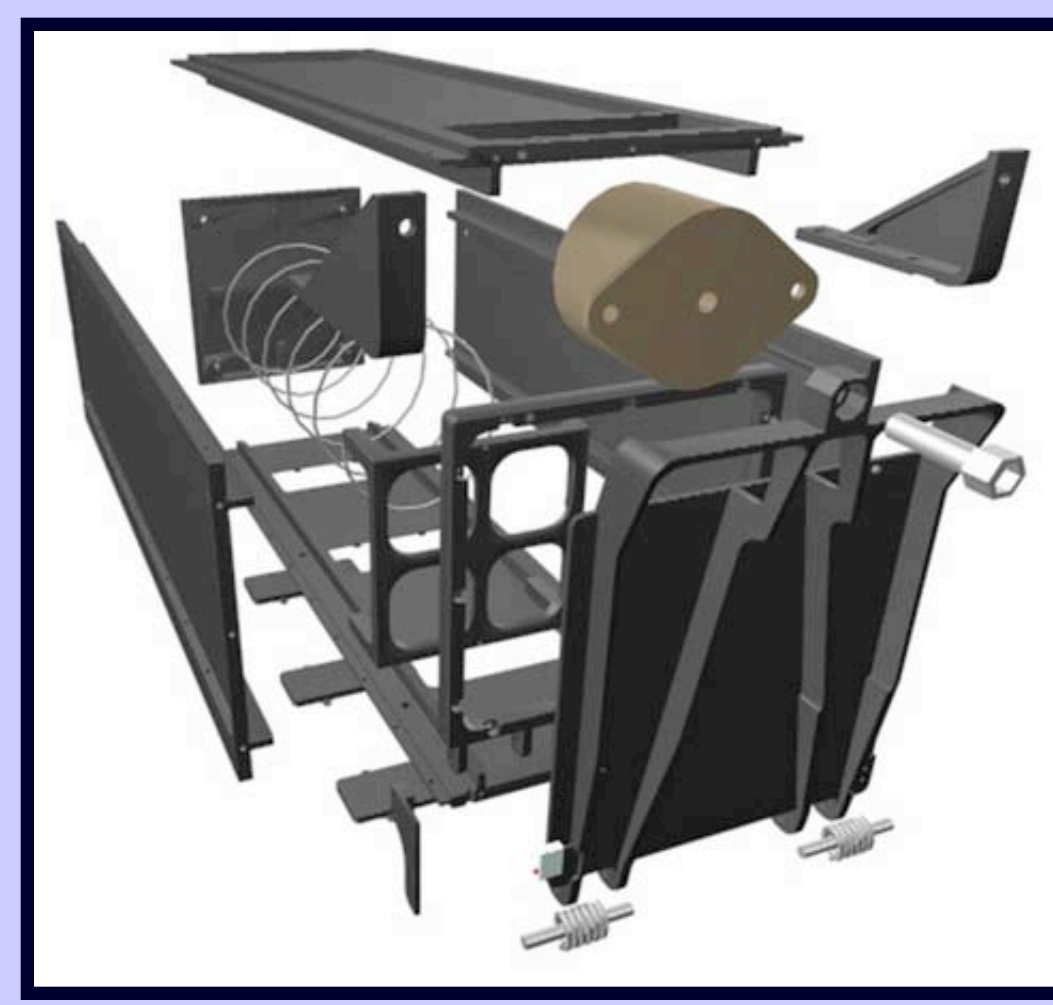
- Satellite three-dimensionally printed with ABSplus
- ABS is acrylonitrile butadiene styrene, a thermoplastic
- Follows the 10 cm x 10 cm x 10 cm standard for a CubeSat
- Records temperature and pressure
- Data with timestamp written to memory on circuit board

Acrylonitrile
Butadiene
Styrene Plus
3D Printed
Satellite



P-POD

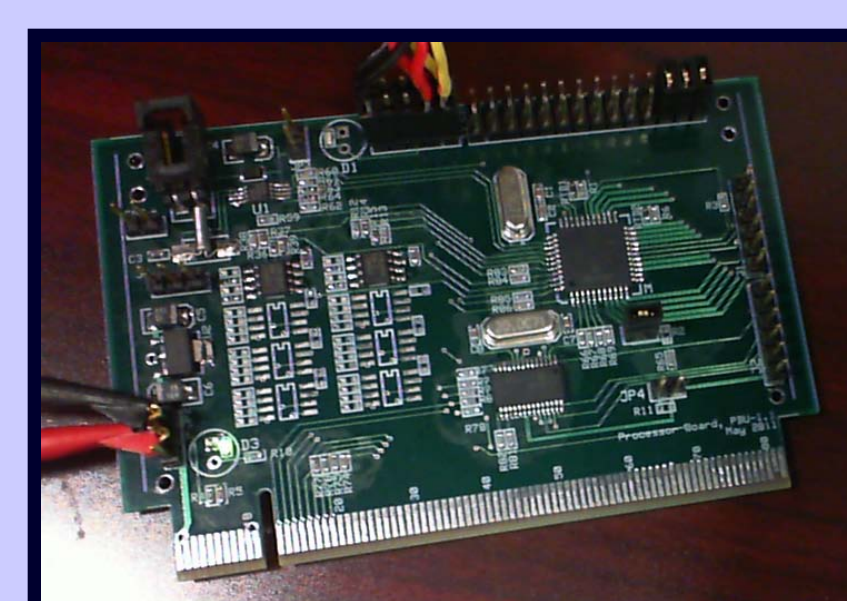
- CubeSats launched from Poly-PicoSatellite Orbital Deployer (P-POD)
- Usually launch 3 CubeSats
- Stores and protects CubeSats during launches
- Ejects the satellites with a spring after door opens



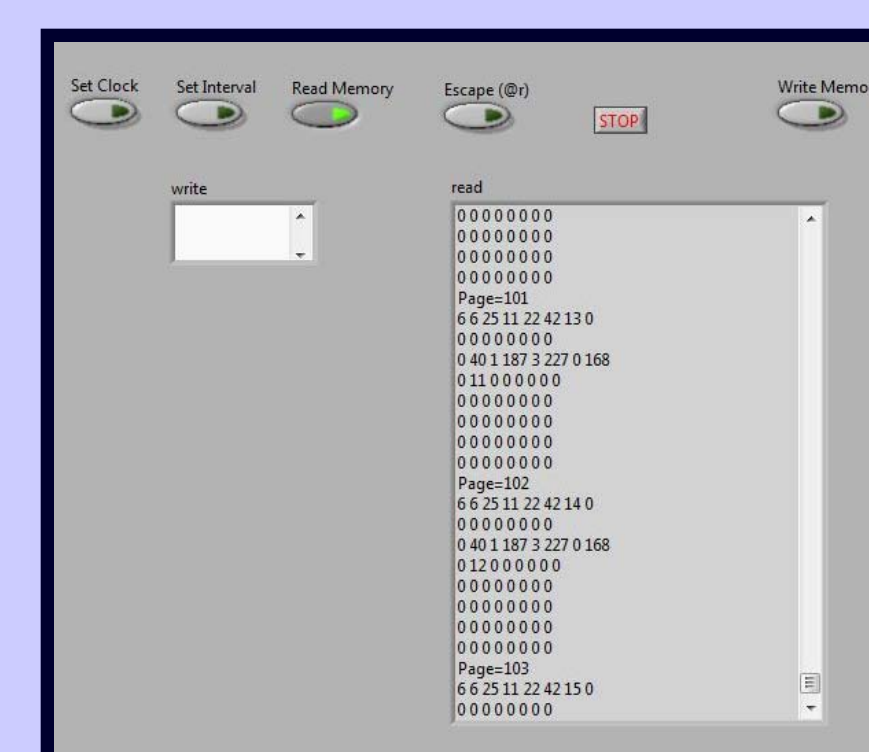
P-POD Renderings: Image from CubeSat *In the News*

Communication and Data Conversion

- Data Collection started with prompt from computer before flight
- Collection continued until memory full
- Data read in lab after flight and retrieval
- Communications between satellite and computer achieved through RS-232 Serial Port connection
- Program interface allows user to set clock, set sampling interval, read data, or begin data collection
- Memory written in 10-bit format converted to decimal format to improve readability



Satellite's Circuit Board



Reading Memory

References

- A. Toorian, E. Blundell, J S Suari, R Twiggs (2005) *Cubesats as Responsive Satellites* CubeSat *In the News*. Web. 18 July 2011. <<http://www.cubesat.org/index.php>>
 "NASA - Students Send Balloons to the Stratosphere." NASA - NASA.gov. Web. 18 July 2011. <http://www.nasa.gov/centers/glenn/technology/explorers_balloons.html>.
 "The Stratosphere." *Windows to the Universe*. Web. 17 July 2011. <<http://www.windows2universe.org/earth/Atmosphere/stratosphere.html>>.

Table 1: Data Read from Satellite (10-bit Format)

The row after the page number (page n corresponds to the n^{th} sample starting from 0) gives the date and time of collection.

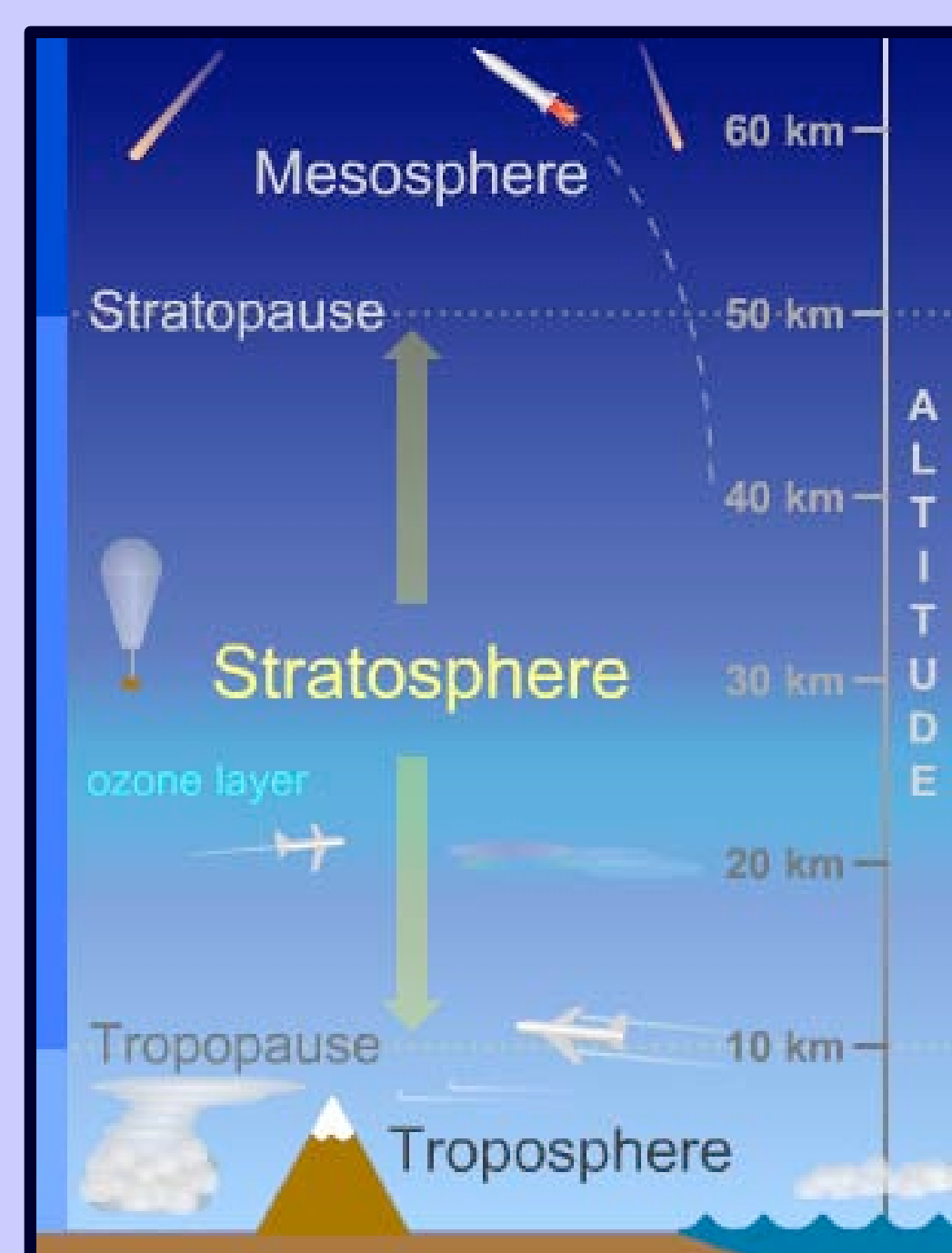
Page0							
4	6	23	11	13	15	51	0
0	0	0	0	0	0	0	0
0	0	1	95	3	215	0	150
0	33	0	0	0	0	0	0
Page1							
4	6	23	11	13	15	52	0
0	0	0	0	0	0	0	0
0	0	1	95	3	215	0	150
0	33	0	0	0	0	0	0
Page2							
4	6	23	11	13	15	53	0
0	0	0	0	0	0	0	0
0	0	1	95	3	215	0	150
0	33	0	0	0	0	0	0
Page3							
4	6	23	11	13	15	54	0
0	0	0	0	0	0	0	0
0	0	1	95	3	215	0	150
0	32	0	0	0	0	0	0

Table 2: Data in Decimal Format

The page number is in the far left column, followed by the date. Time (in the third column) has been converted to seconds from the first sample.

0	6/23/11	0	0	0	0	0	0	351	983	150	33	0	0	0
1	6/23/11	1	0	0	0	0	0	351	983	150	33	0	0	0
2	6/23/11	2	0	0	0	0	0	351	983	150	33	0	0	0
3	6/23/11	3	0	0	0	0	0	351	983	150	32	0	0	0

Balloon Satellites



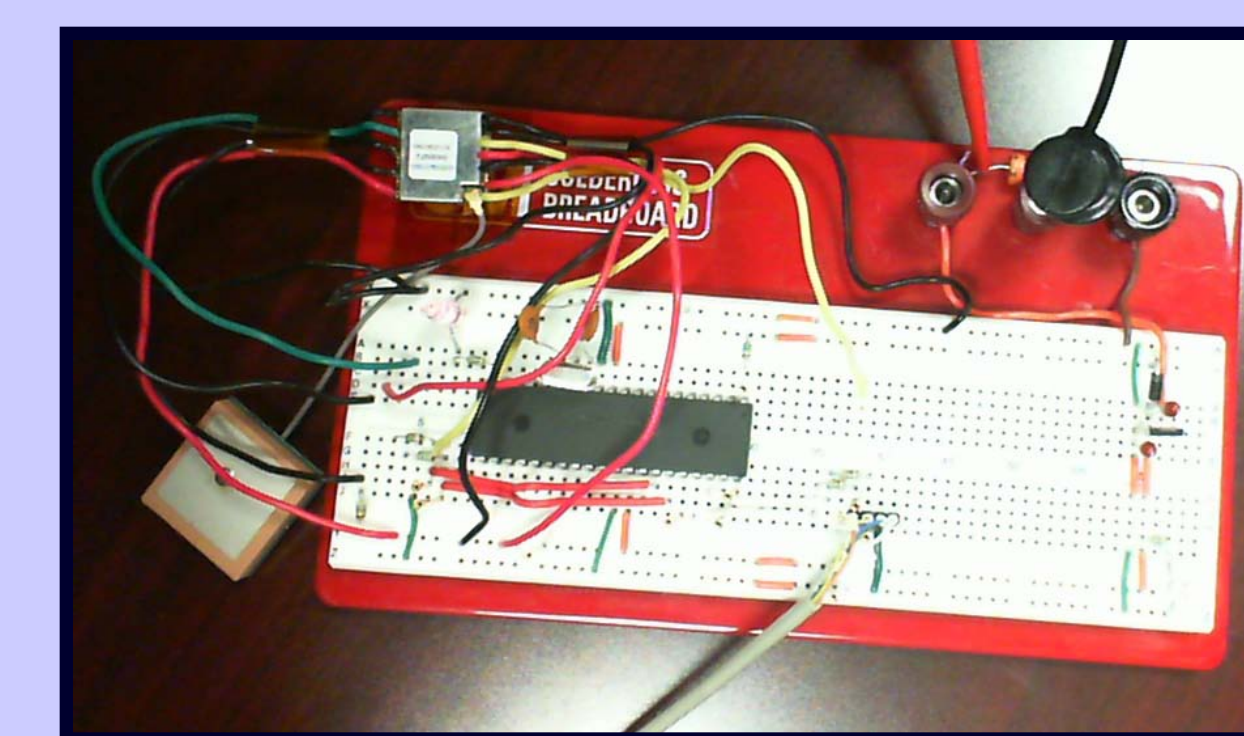
Air Traffic in Layers of the Atmosphere: Image From Windows to the Universe

- Payload attached to helium weather balloon
- Size and weight not standardized
- Rise into the stratosphere
- Reach high enough altitudes to image the curvature of the Earth
- Deflate and return to Earth's surface
- Can be used for near space testing of CubeSats
- Tracked and retrieved after landing

- Lower development and launching costs than CubeSats
- Low costs allow room for error and experimentation
- More accessible than CubeSats
- Limits placed on payload based on volume of satellite and mass that can be carried
- Power for instruments comes from battery during flight

Future Work - GPS

- Ongoing plans include incorporating GPS in the balloon satellite
- Testing GPS on breadboard before inclusion
- Communication using serial port and NMEA protocol
- Provides information about position and speed relative to ground



GPS and Antenna on Breadboard

```
SGPGSV,1,1,00,79
SGPRMC,001355.064,V,0.0,010209,,N,47
SGPGA,001356.063,M,0.0,M,0.0,M,0000*52
SGGSA,A,1,,,,,,,,,,,,,1E
SGGSA,A,1,,,,,,,,,,,,,1E
SGPRMC,001357.075,V,0.0,010209,,N,45
SGPGA,A,1,,,,,,,,,,,,,1E
SGPRMC,001358.063,V,0.0,010209,,N,4D
SGGSA,A,1,,,,,,,,,,,,,1E
SGPGSV,1,1,00,79
SGPRMC,001400.076,V,0.0,010209,,N,43
```

Code Read from GPS

Acknowledgements

Thanks to the University of Arkansas and the Arkansas Center for Space and Planetary Sciences for providing this REU. Funding for this project was provided by the National Science Foundation, Award Number 0851150. Funding for the lab is provided by the Arkansas Space Grant Consortium.