Cooperative Balloon-Satellite Eclipse Measurement

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ABSTRACT

Six high altitude balloon payloads were built and flown in the path of totality on during the 2017 total solar eclipse across the US. The payload flight controllers consisted of Raspberry Pi computers running code written in Bash and Python 3.4 to collect and store data from sensors. The program on each payload collected data from an external temperature sensor, an internal temperature sensor, a pressure sensor, a light sensor, a GPS unit, and a camera. The design also incorporated a smart internal heater to prevent the payload from freezing. The payload design, circuit, and code will be presented along with lessons learned and plans for future work.

Collaboration

Six payloads were built to be flown during the eclipse. One was flown by the Arkansas BalloonSat team, but the other five were shipped to collaborator groups. The collaborators flew the payloads and mailed them back.

Two of the payloads failed to collect any significant data, and the wrong kind of pressure sensors were used. The remaining four payloads, however, collected pictures, GPS readings, temperature measurements, and light measurements.

Below are visualizations of the GPS data collected by each of the payloads. Note two things: 1) The data cuts-off in the middle of flights; and 2) The data quality is poor at the beginning and near the cut-off.

The path of totality of the 2017 total solar eclipse

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Moneta, WY launch

Binford, WY launch

Mitchell, NE launch

Fulton, MO launch

The flight of payload #3 from Moneta, WY

The flight of payload #6 from Binford, WY

The flight of payload #4 from near Mitchell, NE
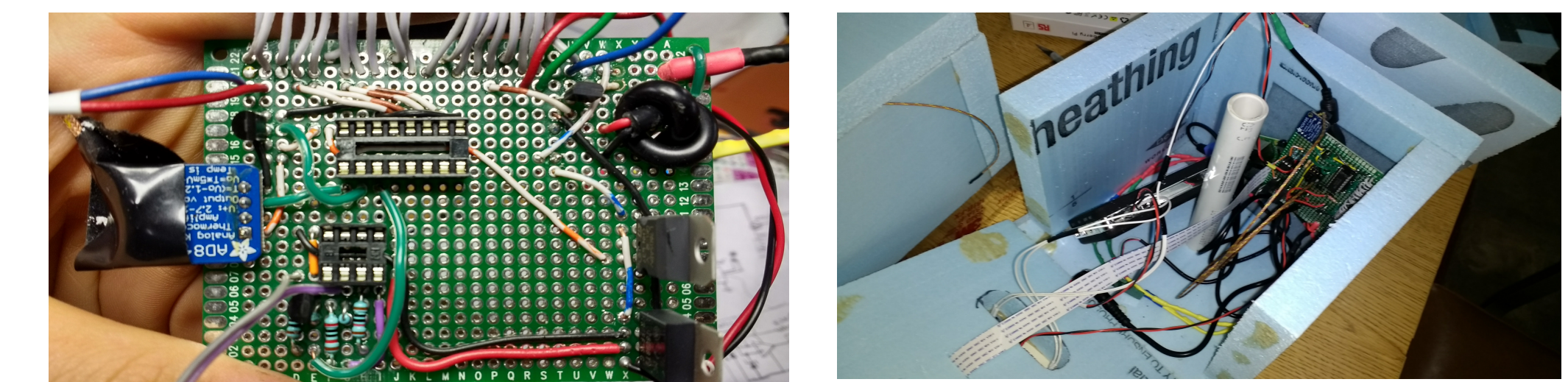
The flight of payload #2 from Fulton, MO

Data Collected

Below are scatter plots of the voltage data collected by the light sensors and the outside thermocouples by sample number. Measurements were taken approximately once per second for the durations of each flight, respectively. Due to time restrictions, the light sensor calibration was recorded, but not included in the program.

Analysis and correlation of the data is ongoing, but the light data will be compared to a relationship of two disks overlapping, and the temperature data will be compared to common models and previously collected data.

Graphs of Light by Sample Number

Light Sensor Data from Payload #2: Fulton, MO

Light Sensor Data from Payload #3: Moneta, WY

Light Sensor Data from Payload #4: Mitchell, NE

Light Sensor Data from Payload #6: Binford, WY

Graphs of Outside Temperature by Sample Number

Outside Thermocouple Data from Payload #2: Fulton, MO

Outside Thermocouple Data from Payload #3: Moneta, WY

Outside Thermocouple Data from Payload #4: Mitchell, NE

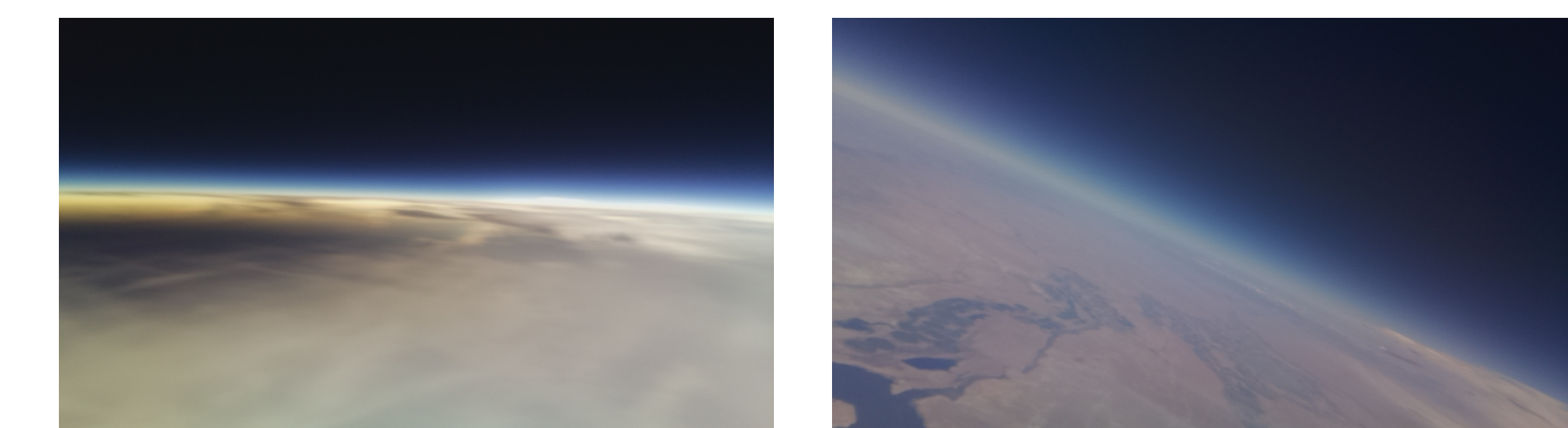Outside Thermocouple Data from Payload #6: Binford, WY

Set-up

The Raspberry Pi was connected by a 40p ribbon cable to the circuit board, which connected the sensors, battery power, heater, analog-to-digital converter chip, the start button, and the indicator LED. The camera and GPS were attached by their own cables, respectively.
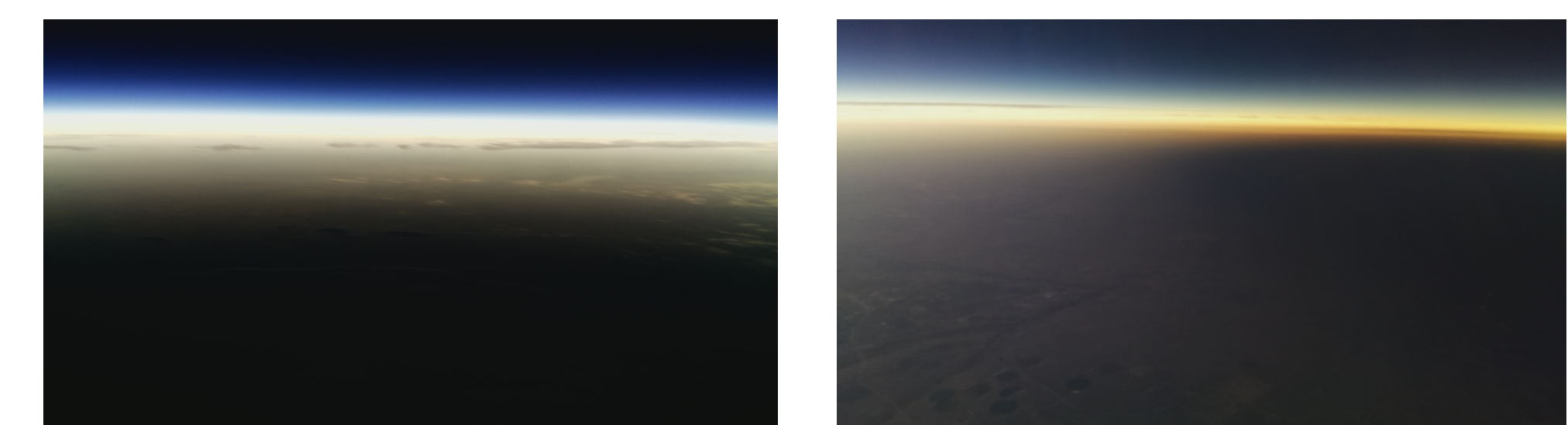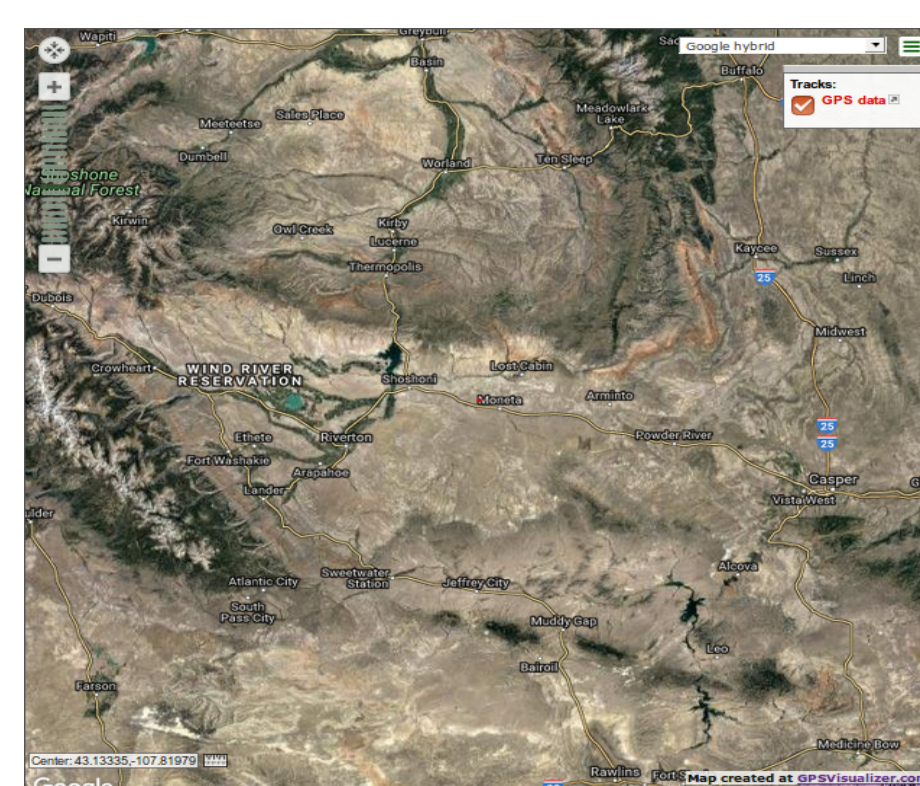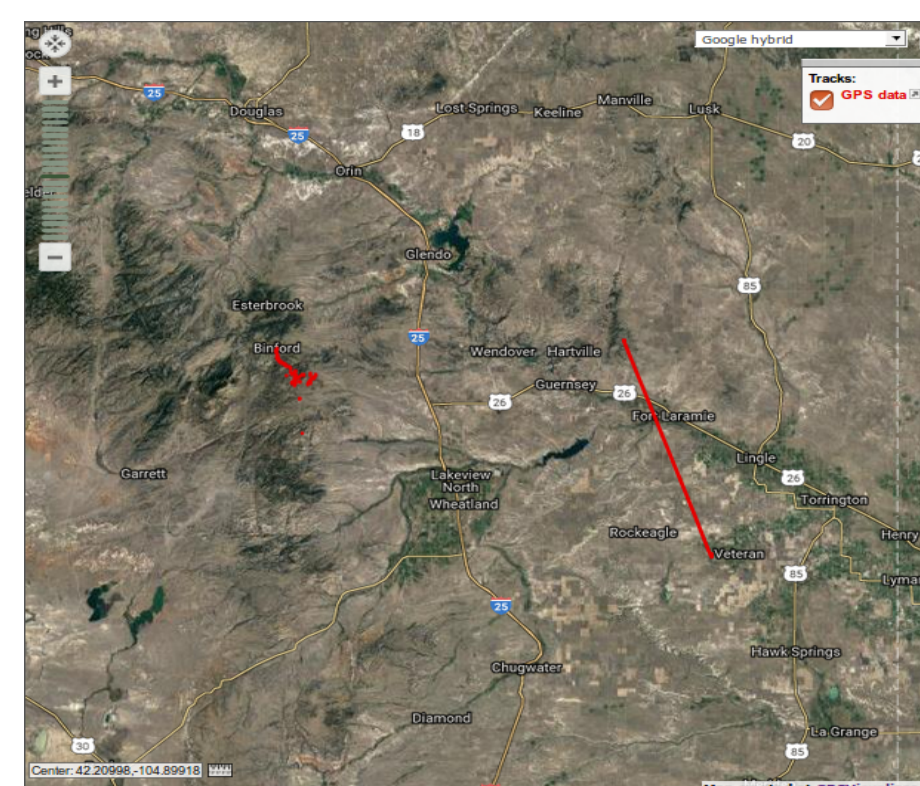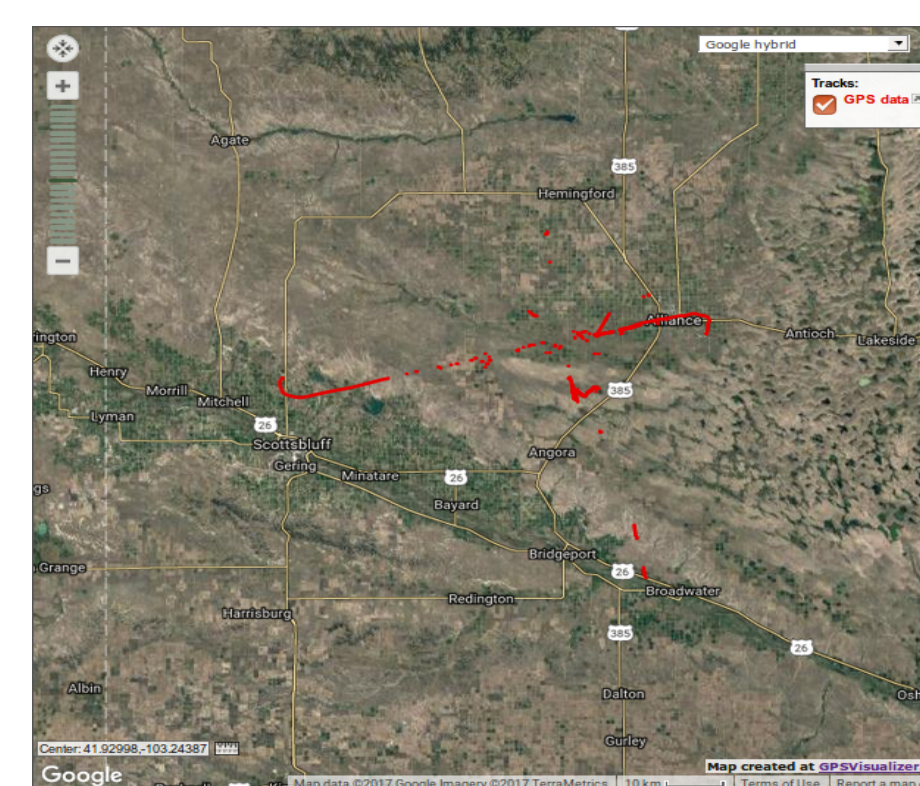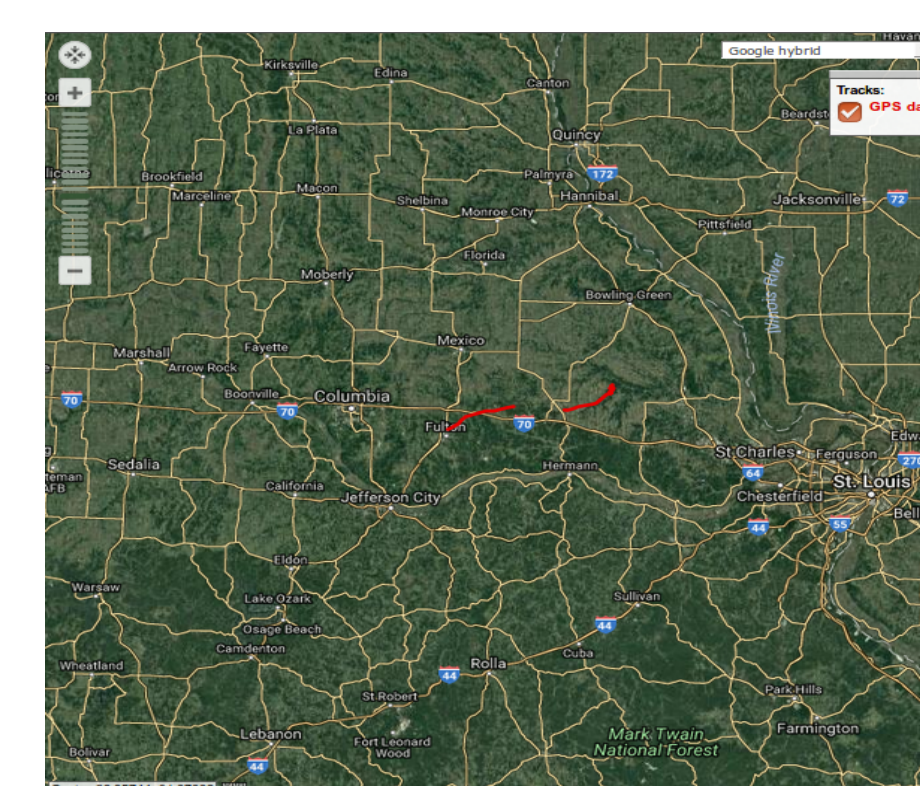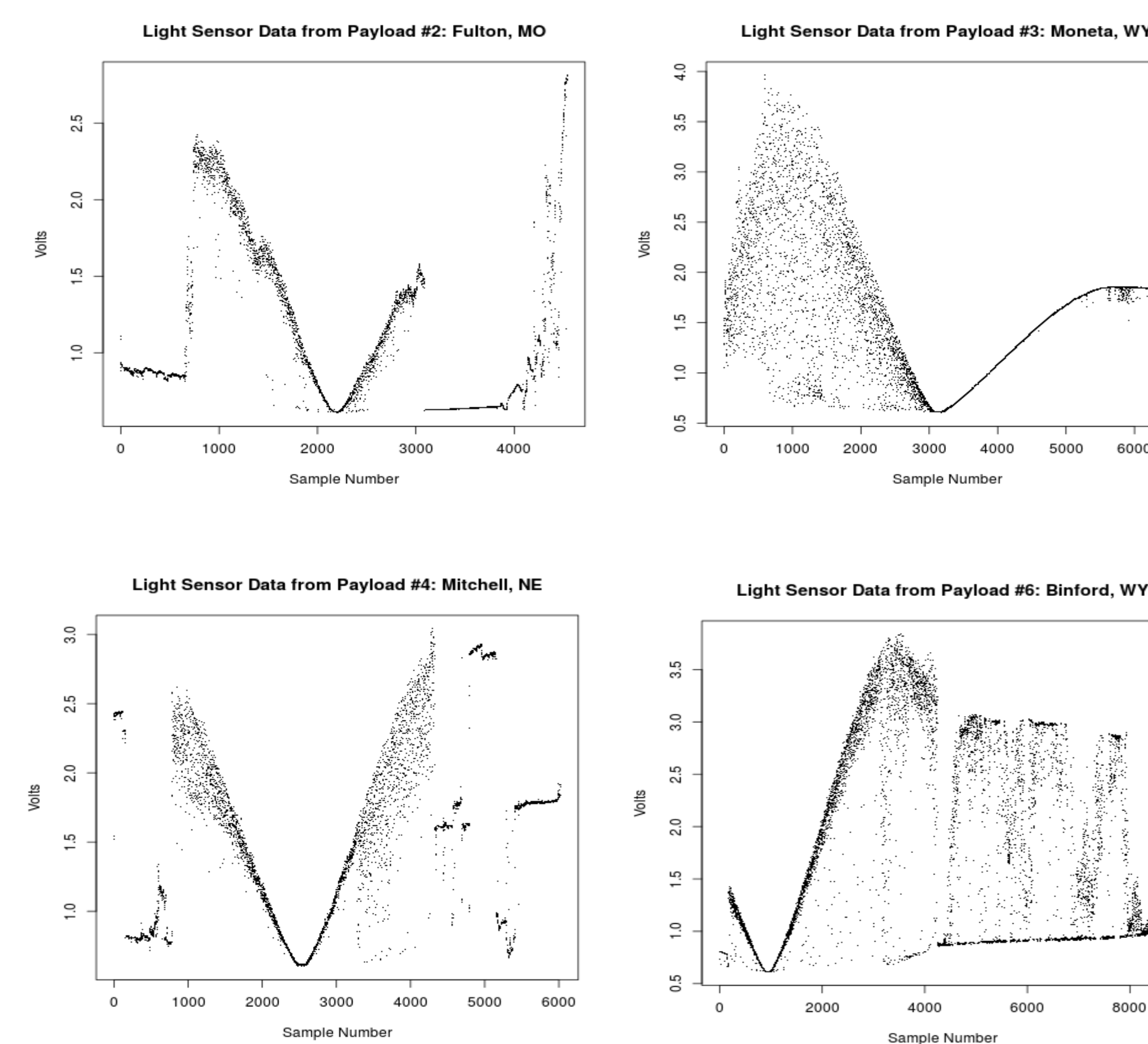
- Above left: A partially completed circuit board.
- Above: a payload box with the electrical components inside.
- Left: four completed payload boxes ready to be weighed.

Payload Pictures

A view of the edge of totality from payload #2 over Fulton, MO

A picture from payload #3 near apex over Moneta, WY

A view from within totality from payload #4 over Mitchell, NE

A view of the edge of totality from payload #2 over Fulton, MO

Future Revisions

In future iterations of the payload design, modifications could be made to correct the following problems:
- The GPS is limited by altitude.
- Data from each sensor was recorded to its own respective file with non-standard timestamps. These both make processing inconvenient.

ACKNOWLEDGEMENTS