High Altitude Thermal Wake Investigation

ST. CATHERINE UNIVERSITY

Presenters: Rachel Hedden & Mara Blish
Co-Author: Amanda Grove
Faculty Advisors: Erick Agrimson, St. Catherine University & James Flaten, University of Minnesota

Introduction

- **Using various temperature sensors we investigated the effects of the thermal wake generated by ascending balloons during high altitude balloon flights (1-3).**

- **The temperature of the air directly beneath the balloon is warmer than the surrounding air due to sunlight hitting the balloon, which warms the air passing close to the balloon forming the thermal wake.**

- **One reference suggests that this thermal effect is only significant within 25 feet of the base of the balloon (2).**

Introduction

- **The use of HOBO temperature probes without the use of sun shields appear to have a more rapid response to temperature changes in the atmosphere (4).**

- **Having the temperature probes be white reduces the absorption due to solar radiation (3).**
  - **This will hopefully result in the sun's rays having less of an effect on the temperature readings.**

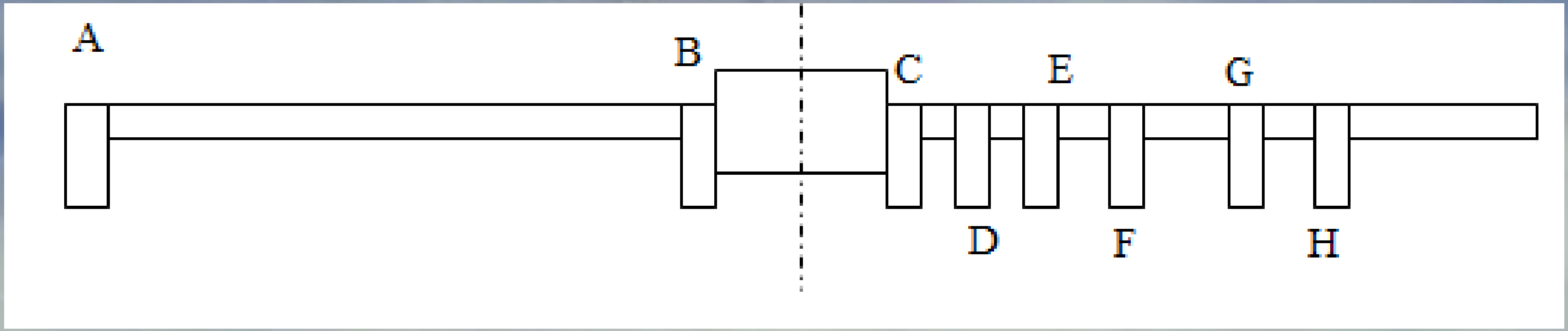
- **The color of the payload and the proximity of the box to the sensors also need to be taken into account.**

Primary Research Questions for Summer 2013

- What is the width of the observed thermal wake?
- What is the wake temperature profile as a function of altitude for the daytime effect?

Methods

- The wake boom is less than 25 feet from the neck of the balloon.
- The wake-boom experiment has flown on 3 daytime flights since our summer 2012 report (4). For numbering continuity with the summer 2012, these flights will be called 6D, 7D, and 8D. The basic parameters of the 2013 flights are as follows:
  - 6D: The boom reached 80,410 ft. It had 6 temperature probes: one white-painted and one (Al-colored) both located 7 cm from the (black) payload box, then white-painted sensors taped under the (black) boom at 53 cm, 94 cm, and two at 156 cm from the center of the wake.
  - 7D: The boom reached approximately 90,000 ft. The boom had 8 white-painted temperature sensors, two located at 7 cm on either side of the (black) payload box, there were sensors taped under the (black) boom at 35 cm, 53 cm, 78 cm, 94 cm, 142 cm, and 156 cm from the center of the wake.
  - 8D: The boom reached 84,846 ft. The boom had 8 white-painted temperature sensors, two located at 7 cm on either side of the (half white; half black) payload box, there were sensors taped under the (now-white) boom at 13 cm, 19 cm, 25 cm, 35 cm (this sensor malfunctioned so its data is not presented), 43 cm, and 155 cm from the center of the wake.



Methods

- **The temperature probes were roughly the same distance from the center of the payload on both sides for flight 6D and 7D.**
- **The placement of the temperature sensors were measured.**
- **The carbon fiber tubes comprising the structure of the wake boom are naturally black. For flight 8D we taped over the black carbon fiber tubing.**

Flight 8D

Figure 1: The Change in Temperature Throughout the 8D Flight For White-Painted Sensors

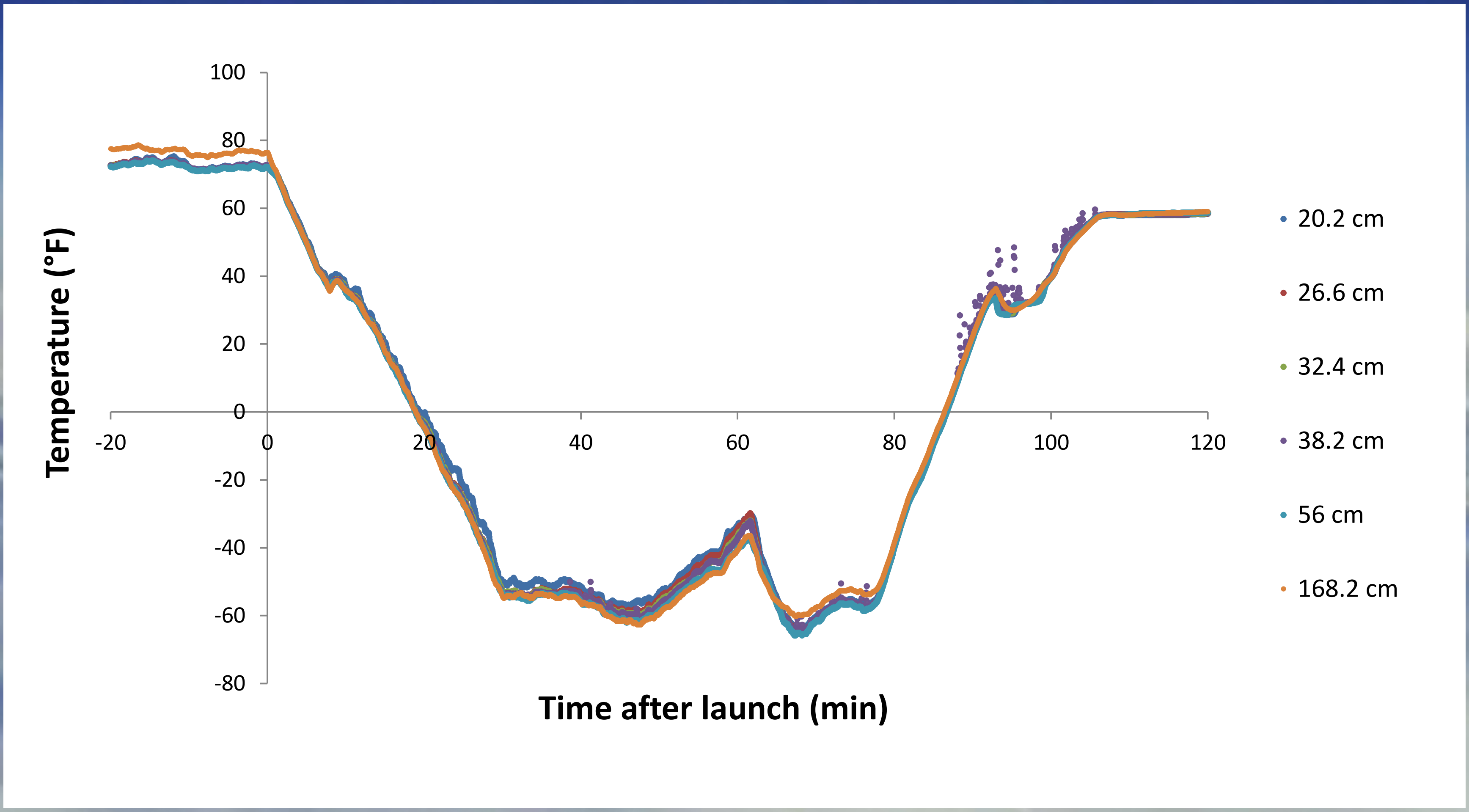


Figure 2: The Change in Temperature in Flight 8D as the Balloon Enters the Stratosphere

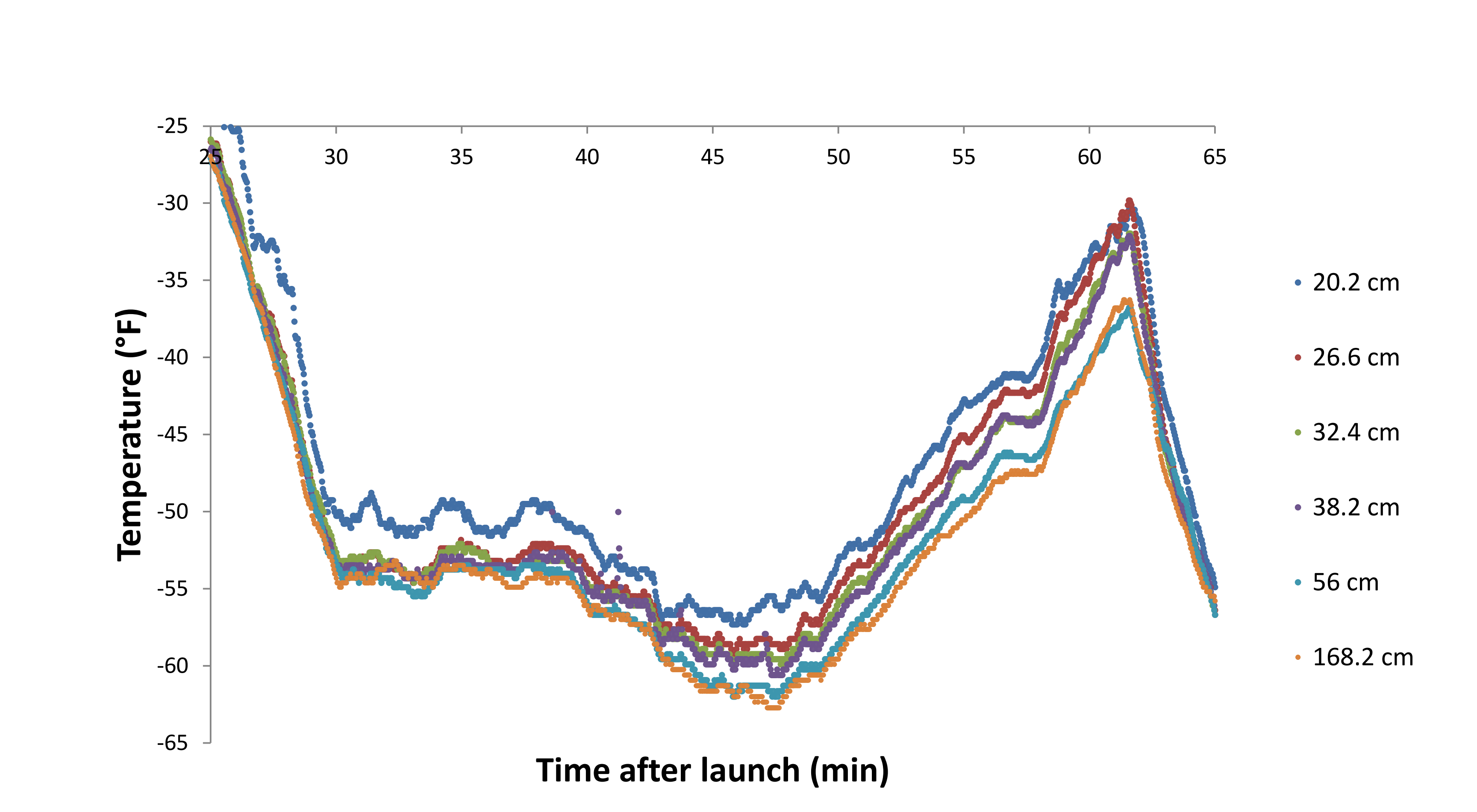


Figure 3: The Temperature During Flight 8D Before Balloon Burst in the Stratosphere

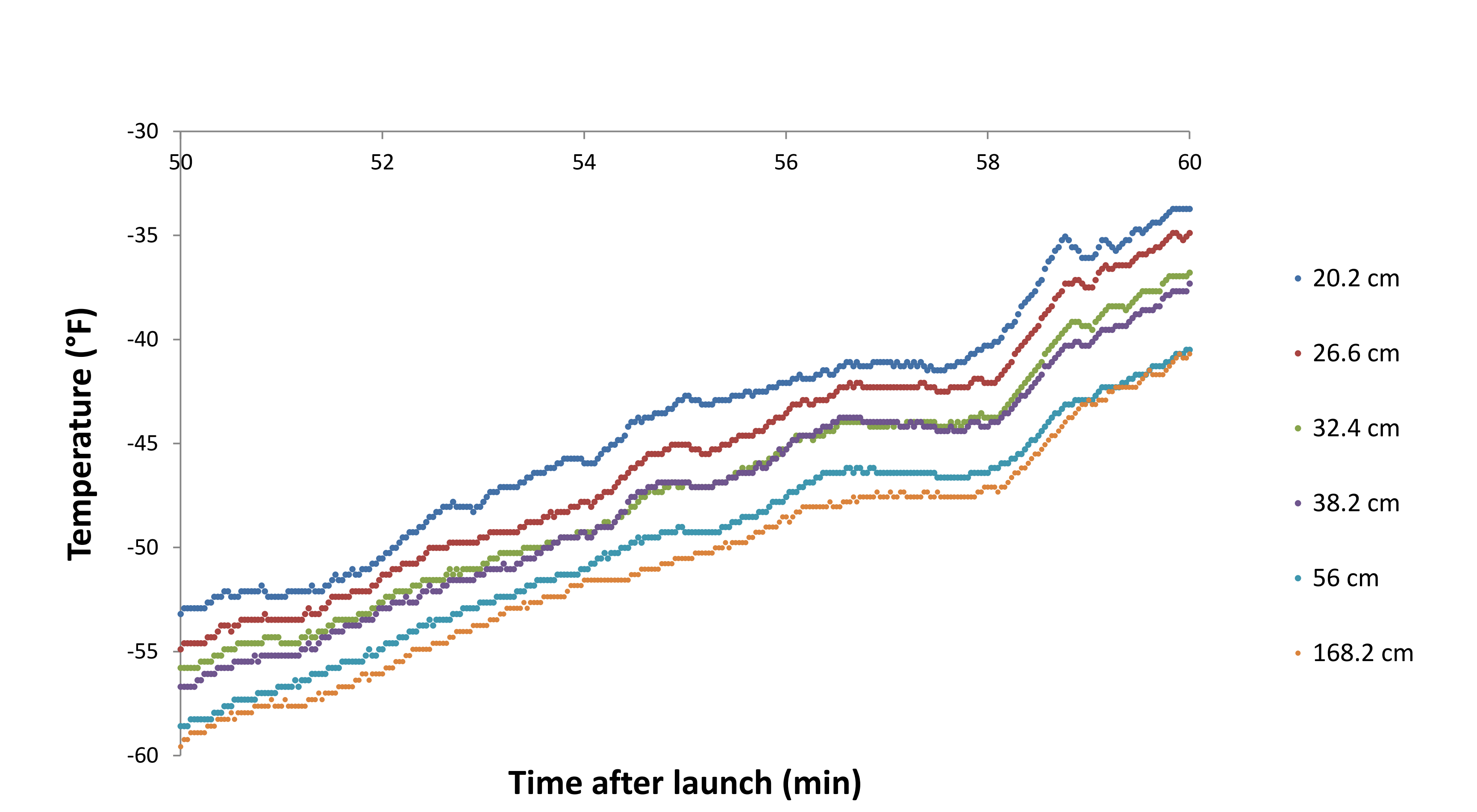
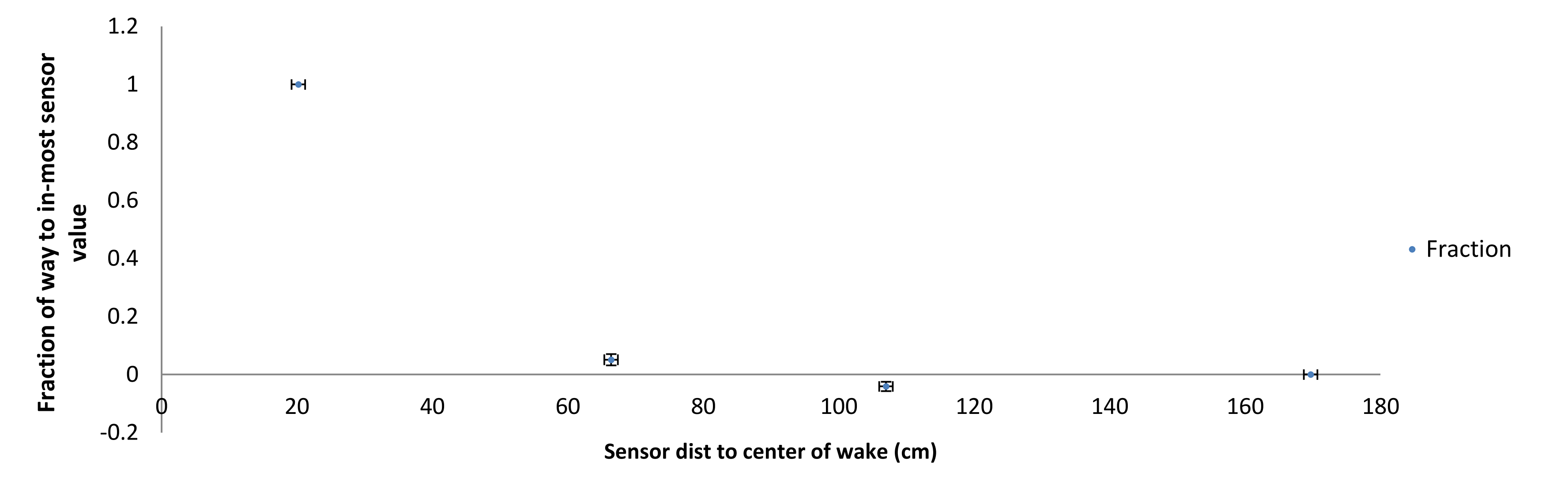


Figure 4: The Effect of the Sensor Distance From the Center of the Wake Boom



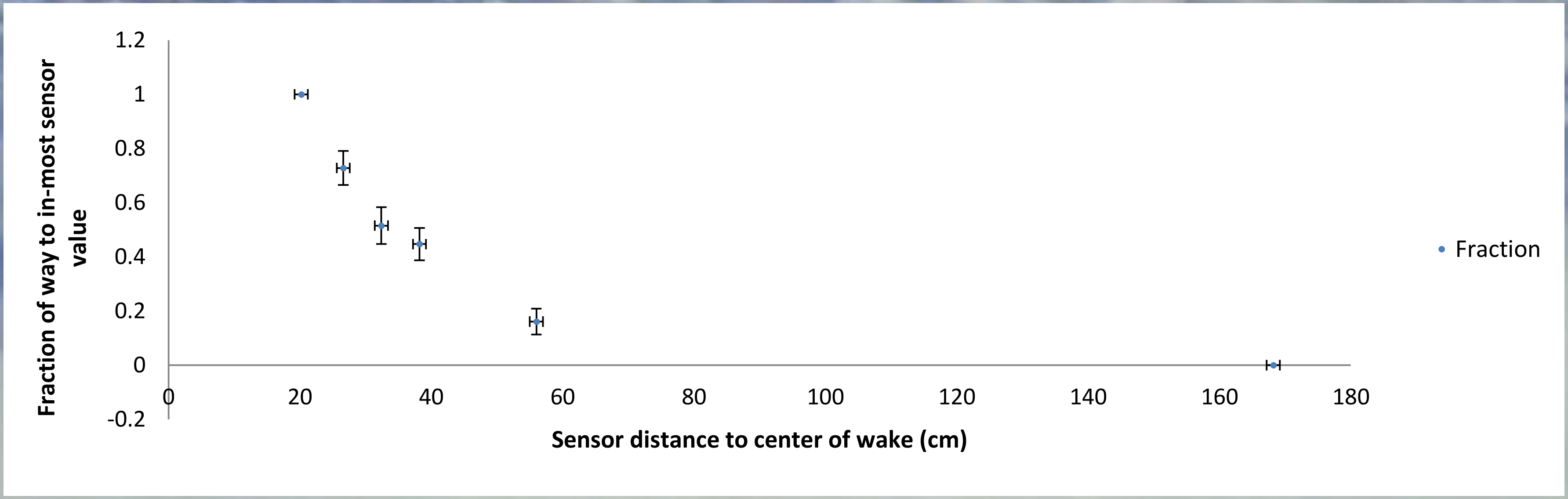


Figure 5: Impact of a black versus a white-colored payload box

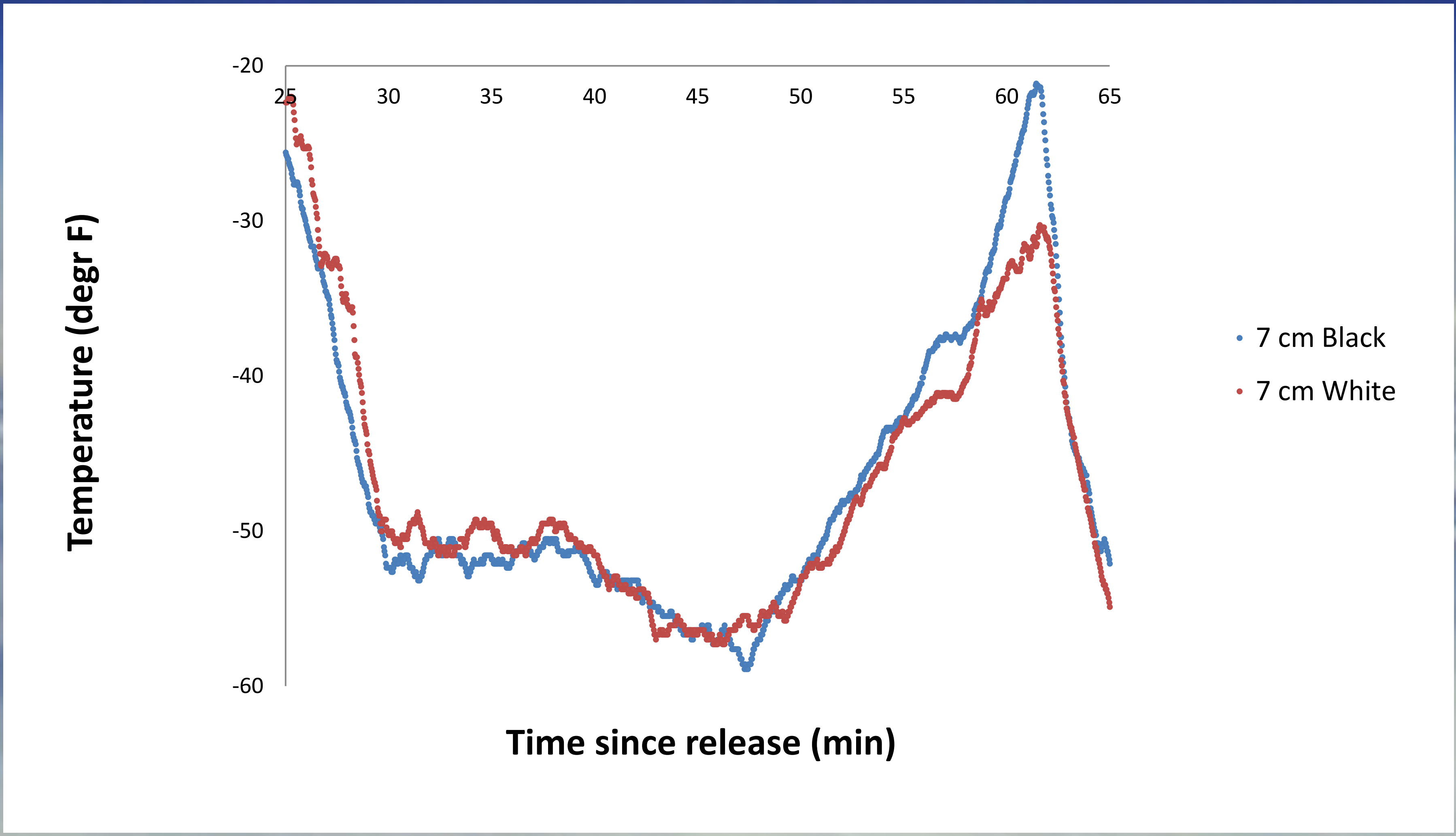
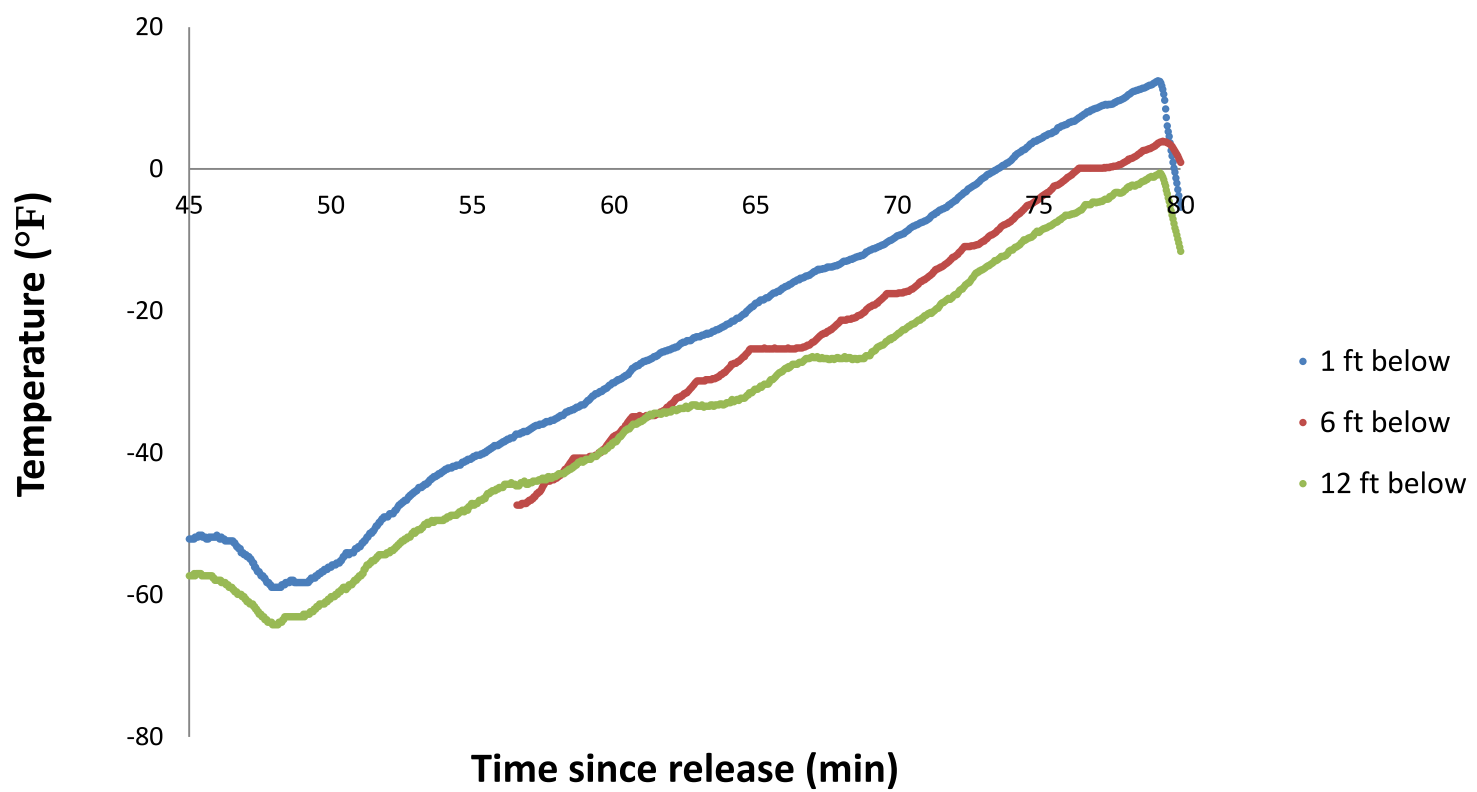
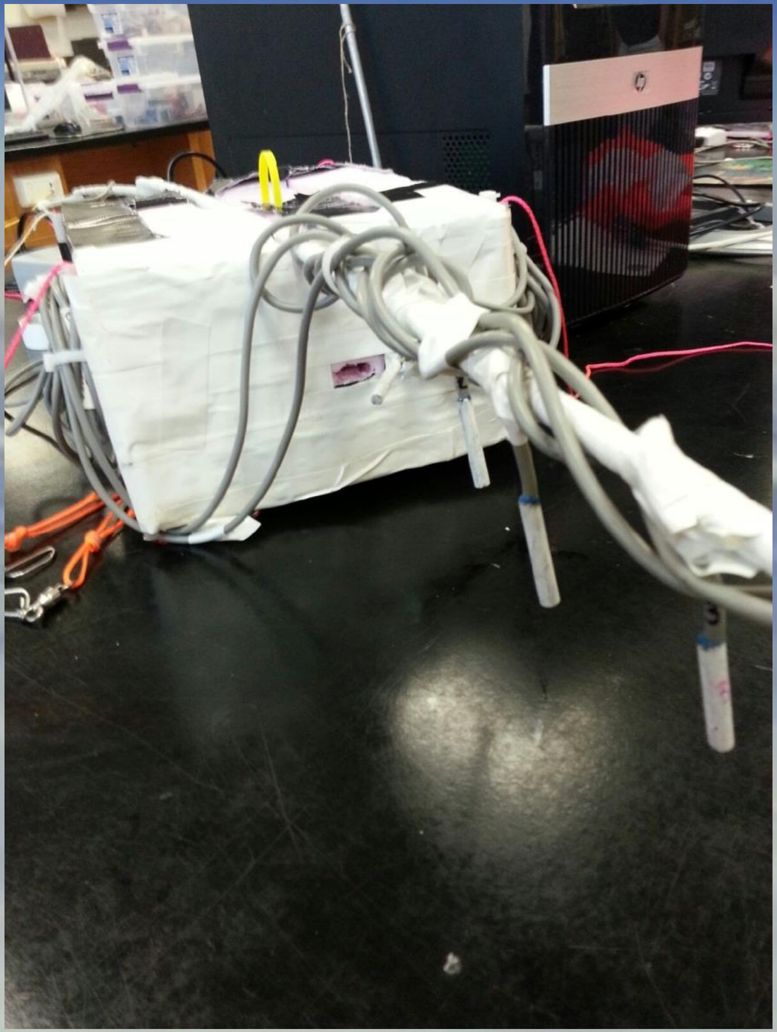


Figure 6: Temperature of Flight 7D using Temperature Probes Below the Payload



Discussion

- **Our research shows little to no evidence that there is a compelling change in temperature beyond about 50 cm from the center of the boom (Figure 4).**
- **Tiefenau and Gebbeken theorized there is a bell-shaped temperature profile as one moves from the center of the wake out (1).**



Conclusion

- **In our flights so far this summer we have been able to profile temperature differences as a result of the thermal wake (figure 1-3 & 6)**
  - **As the distance from the center of the payload increases the temperature decreases.**

Future Considerations

- **Looking at the wake temperature profile as a function of altitude for the nighttime effect and compare it to the daytime data (1).**

- **Positioning temperature probes inside the thermal wake as well as increasing the number of temperature probes altogether.**

Future Considerations

- **We may move the boom above the payload box containing the HOBO data loggers, allowing us to place sensors at the very center of the wake in future flights.**
- **Experimenting with different types of temperature collection apparatus (i.e. non HOBO sensors).**
- **A more uniform fill of He for comparative flights coupled with consistent payload weight for wake flights**

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Starting from left: Rachel Hedden, Mara Blish, Spencer McDonald, Toni Carlstrom, Amanda Grove, and Professor Erick Agrimson

References

1. Tiefenau, H. and Gebbeken, A. *Influence of meteorological balloons on Temperature Measurements with Radiosondes: Nighttime Cooling and Daylight Heating,* J. Atmos. and Oceanic Tech. **6** (36-42), 1989.
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4. Agrimson, E. and Flaten, J. *Using HOBO data loggers with Air/Water/Soil temperature probes to measure free-air temperature on high-altitude balloon flights*, 3rd Annual Academic High-Altitude Conference, Tennessee, 2012, pp. 20-31.