CLIMATOLOGICAL STUDY OF THE SHORT-TERM VARIATION OF THE 0°C, -10°C, AND -20°C ALTITUDE LEVELS OVER THE FLORIDA SPACEPORT

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Background

- Launching through electrified clouds resulting in triggered lightning is a primary weather hazard to spaceflight operations.
- For evaluation of the potential of cloud electrification, it is necessary to know the altitude of the 0°C, -10°C and -20°C levels.
- In support of rocket launches, often multiple balloons are launched within minutes of each other in the 4-6 hours leading up to launch.
- In the past, temperature data from sondes was typically available every hour or so through the launch countdown, allowing for frequent updates of these critical temperature thresholds.
- Recently, launch customers are relying on jimsphere and wind profiler data that do not have a thermodynamic component in the latter 4-6 hours of a countdown.

Project Goals

This project attempts to answer the following questions:

- Does the altitude of the 0°C, -10°C and -20°C levels vary by more than 500 ft* within the launch countdown window (6 hours or less)?
- If these altitudes do change by 500 ft or more within this window, how often does this occur?
- Should additional low-resolution sondes with thermodynamic data be released closer to launch than T- 4 hours to T-6 hours?

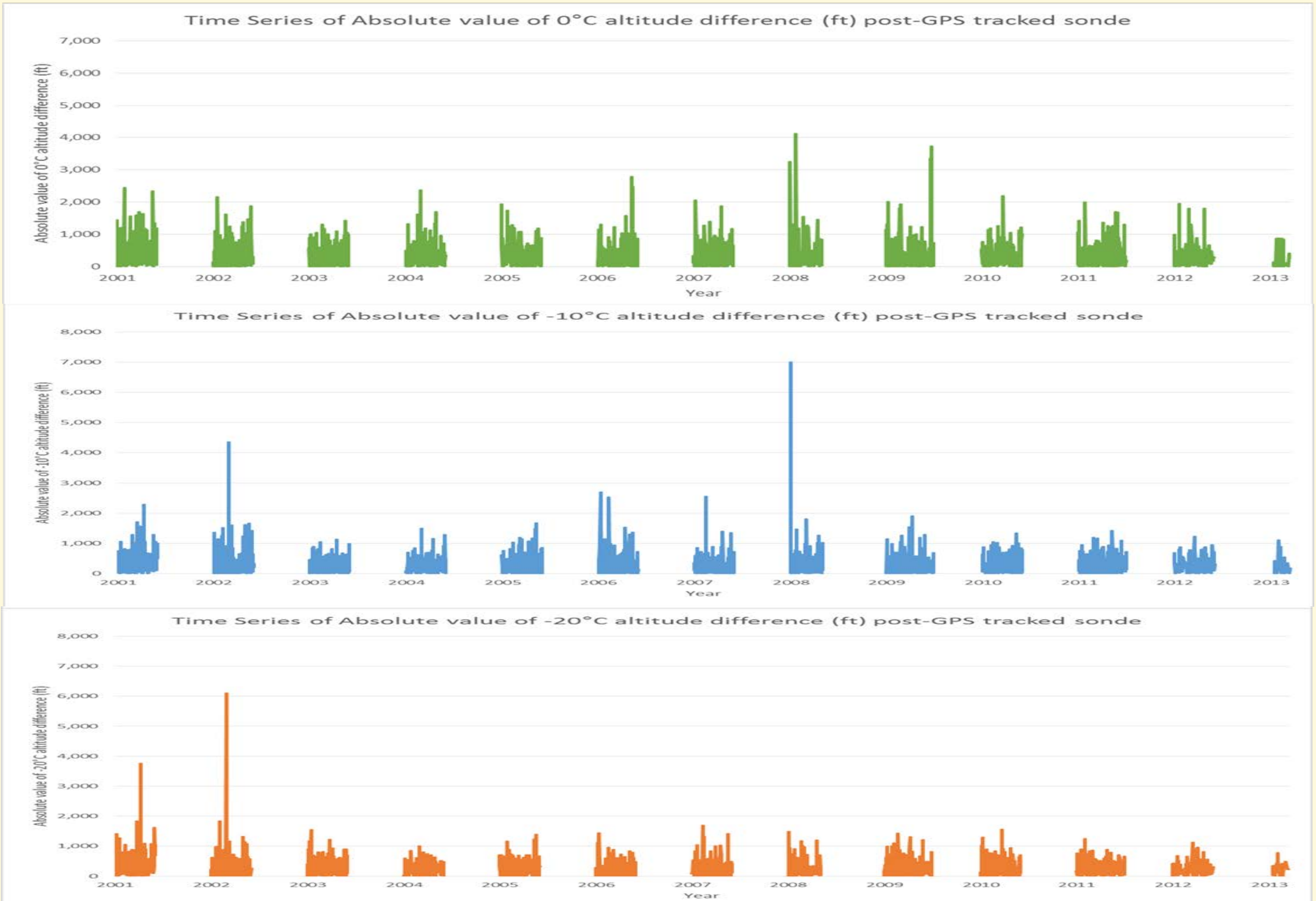
*500ft is close to the operational limit of the radar, so changes greater than
that are technically detectable. 1,000 feet fits an easily identifiable range on the radar and is a convenient number for humans to interpret.

Data Used

- GPS-tracked sondes (2001 through 2013)
- Warm season (May through September) since Eastern Range reliably has at least one pair of rawinsondes launched less than 6 hours apart during this period
    - 0°C level: 3,198 pairs of rawinsondes
    - -10°C level: 3,120 pairs of rawinsondes
    - -20°C level: 3,072 pairs of rawinsondes

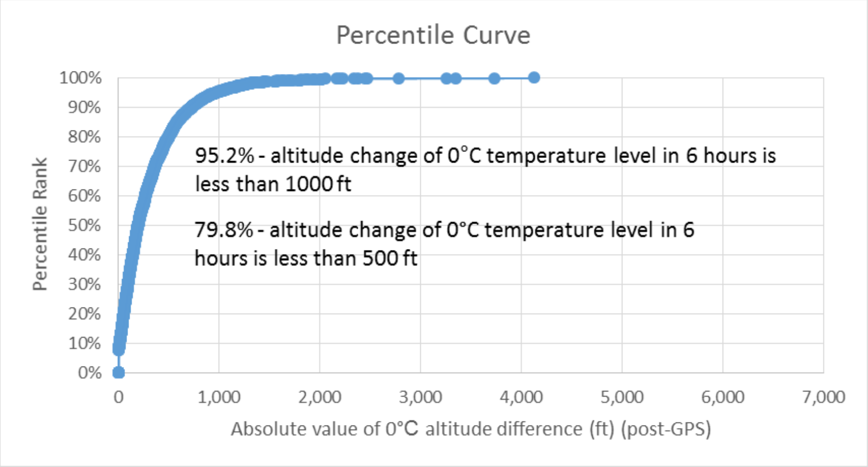
Data Used

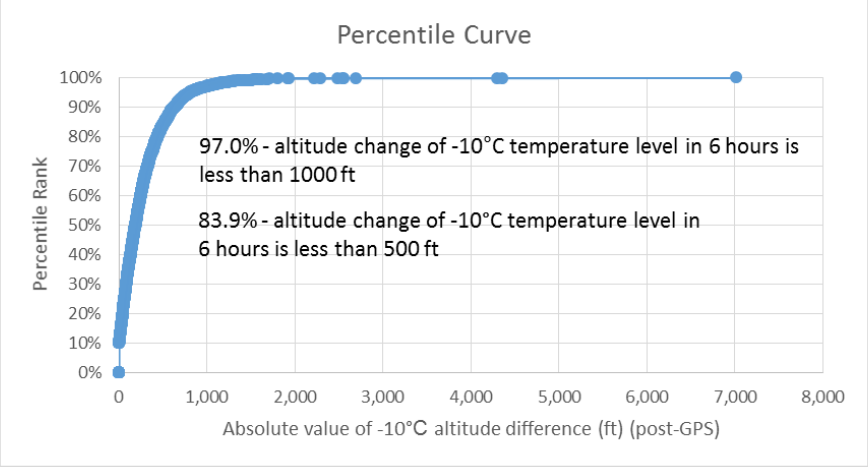
Time series of temperature level altitude changes by year (2001 through 2013 warm season)

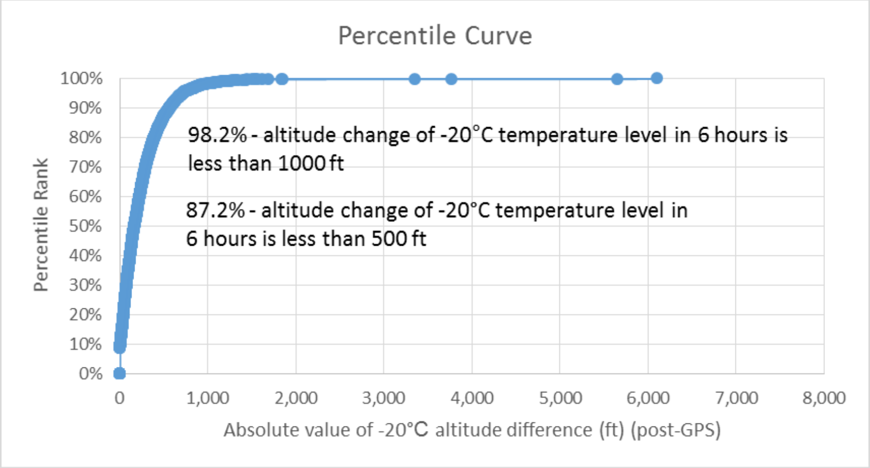


Results

Especially at the 0°C temperature level, short-term (less than 6 hours) changes of 500 ft or more can occur 20% of the time and changes of 1000 ft or more can occur 5% of the time



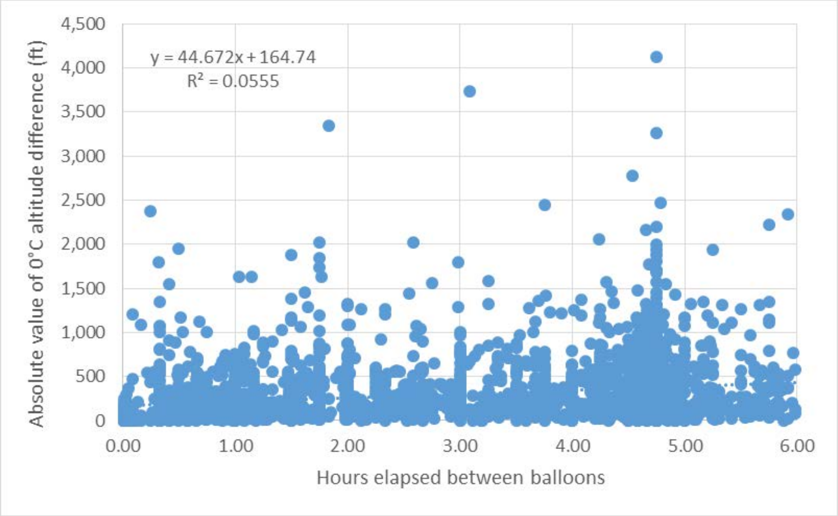


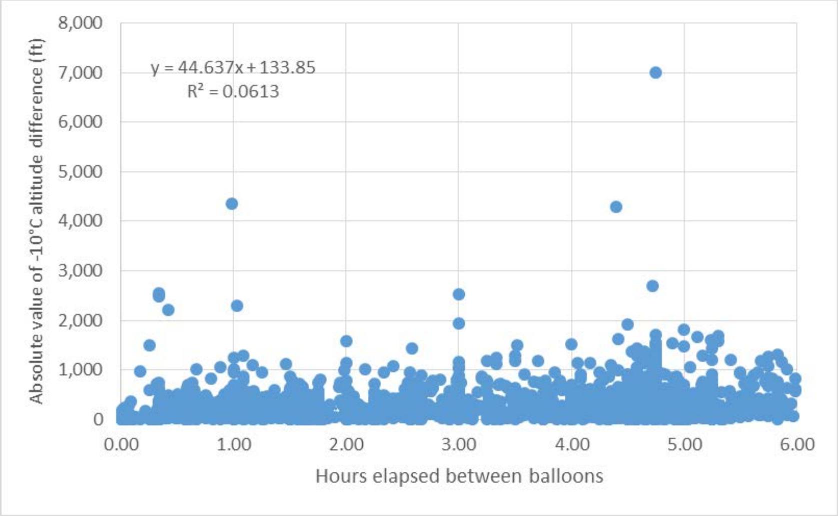


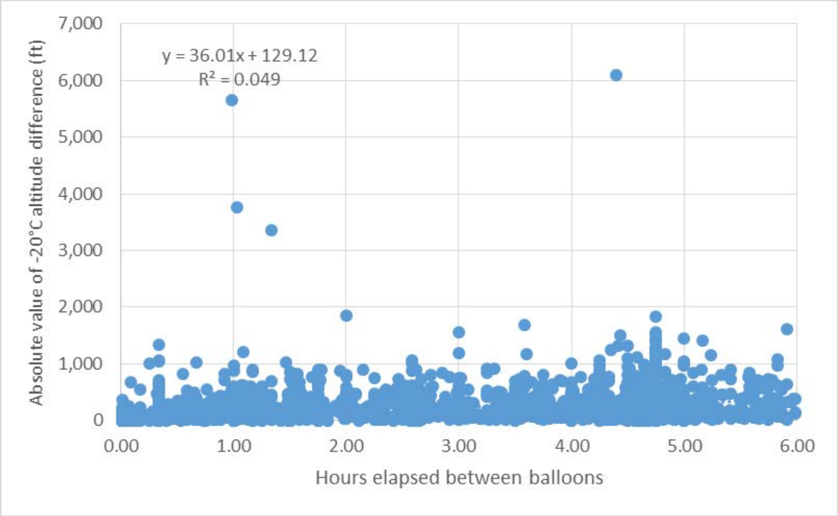
Note: These distributions failed the goodness of fit tests for all of the most common distributions (e.g. normal, log normal, exponential, Wiebull, extreme value, gamma, logistic, etc.), however the percentiles were verified by Monte Carlo analysis.

Results

Little correlation of change in altitude of temperature levels with time



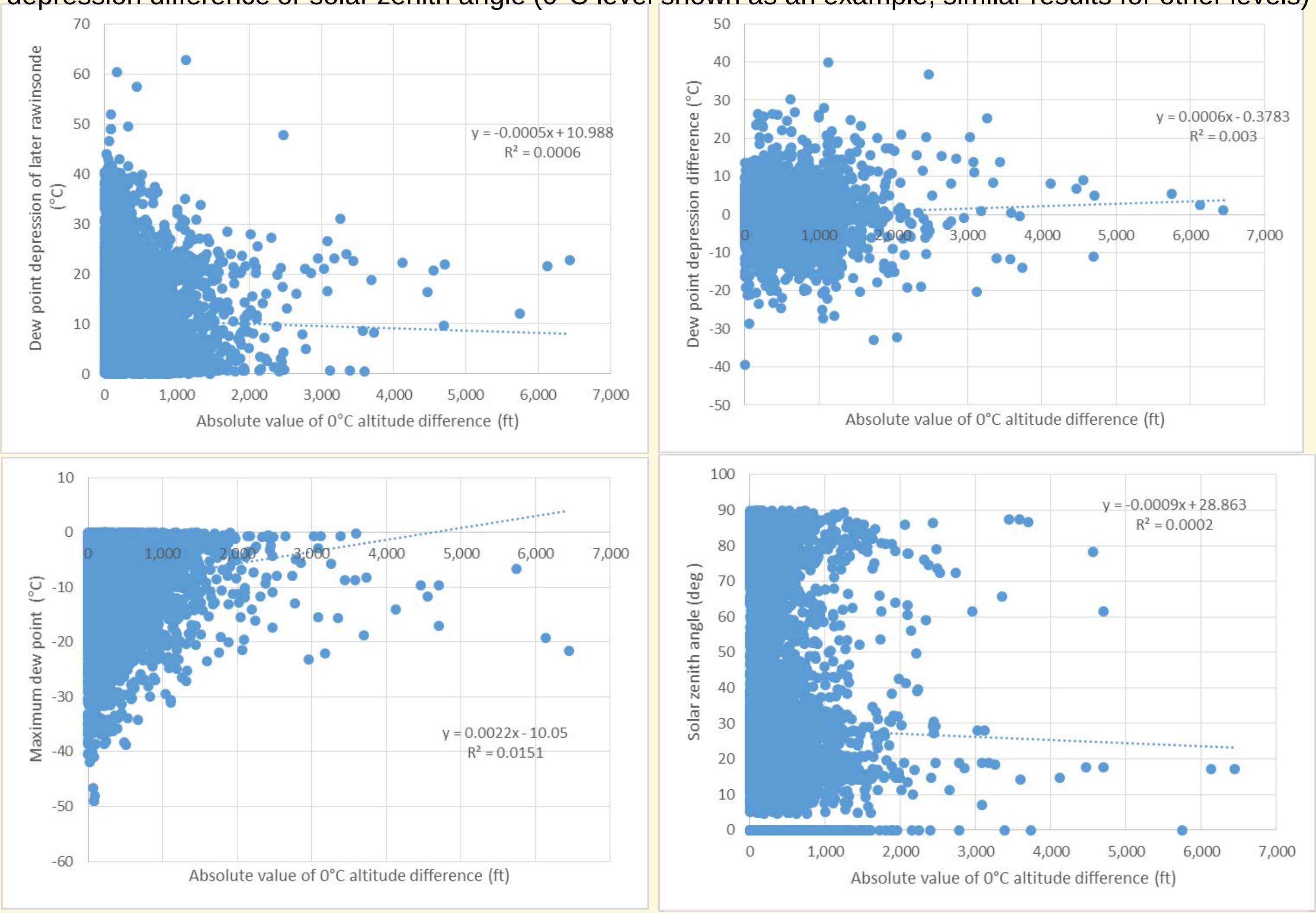




Note: Hypothesis testing was performed for each correlation coefficient and all failed to reject the null hypothesis.

Results

No correlation of change in altitude of temperature levels with dew point depression, maximum dew point, dew point depression difference or solar zenith angle (0°C level shown as an example, similar results for other levels)



Future Work Possibilities

- Update period of record through 2016
- Repeat for more RAOB release time changes (e.g. 8 hr, 12 hr, …,24 hr)
- Stratify data by month
- Develop tool to provide probability of exceeding a user specified temperature level by month

Conclusion

- Short-term changes of 500 ft or more can occur 20% of the time and changes of 1000 ft or more can occur 5% of the time
- No good correlations of changes in temperature level altitudes to time or other variables such as dew point depression or solar zenith angle
- Recommend launch low-resolution rawinsonde closer to T-0 (between T-1 and T-2 hours) since it takes about an hour for the balloon to reach altitude

AMS Theme:
Observations Lead the Way

- Launch community would greatly benefit from a remote sensing capability to measure thermodynamic data with respect to altitude from 300 meters to at least 10 km, but preferably up to 30 km. The technology must have a vertical measurement resolution of 150 m or smaller and a rapid cycle (<= 15 minutes) full vertical profile of the thermodynamic data. The sensor must provide valid data in both cloudy and clear environments.

Questions?