Measurements of Vertical Ambient Temperature by Unmanned Aerosol System

Ryan Thalman

Department of Chemistry, Snow College Richfield, UT

(contact: Ryan.Thalman@snow.edu)

Introduction:

Spatial distribution of pollutants in the atmosphere is an important part of our understanding of atmospheric composition. While airplane platforms allow for vertical and horizontal distribution measurements, these usually are missing the portion of the boundary layer between the ground based sensors (~10 m) and the lowest flight altitude (500-1000 ft above ground level (AGL)). Here we applied the use of an unmanned aerial system (UAS, or drone) to investigate the lower portion of the boundary layer a Vertical Ambient Temperature Quad (VAT-Quad).

Experimental

While there have been previous, more well For this work, a cheap simple solution to gather information about one of the most basic atmospheric properties (pressure, temperature, and relative humidity) was sought to test how to simply probe the lower section of the planetary boundary layer (PBL).

A DJI Phantom 3 Standard drone was equipped with an Arduino controller board with a SD data logger, a clock and a BME-280 pressure, temperature, and RH sensor). The sensor was located in a housing placed 5" forward of the furthest reach of the front propellers. Different flight patterns were tested to understand the variability in the retrieved signal, which could be effected by interference from the propellers, sensor response time, solar radiation, etc. Flights were performed under 14 CFR Part 107 and in compliance with all listed flight regulations.

Results

Altitude was calculated from pressure:

$$Alt\ (m) = \frac{\left(\left(\frac{P}{P_i}\right)^{1/5.257} - 1\right)T}{0.0065} + Alt_i$$

Flight Pattern investigation:

Because the drone moves the air around it to change position, the air through which the sensor is passing may be altered by the drone itself. The following are recommendations for sampling:

-Data acquired on the downward cycle are effected by downward mixing by the drone.

-UAS effected air movement 6-7 meters below the sensor

-Flights were conducted with loops at a given altitude in order to actively move the air in front of the drone across the sensor with the sampled air unaffected by the drone.

Flight levels were spaced out 10 meters AGL apart. Each flight used ~30% of the battery, allowing 2 flights per battery for a total height of 130 m AGL (near a >15 m tall building).

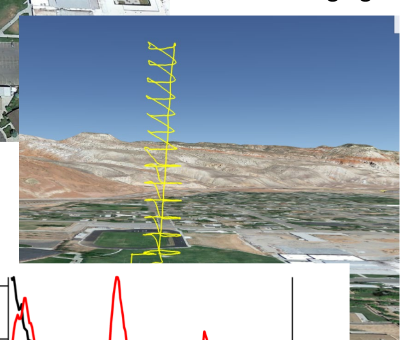
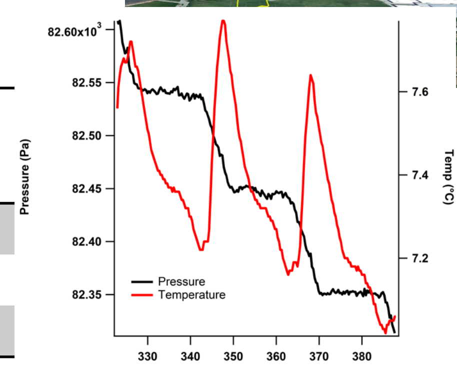
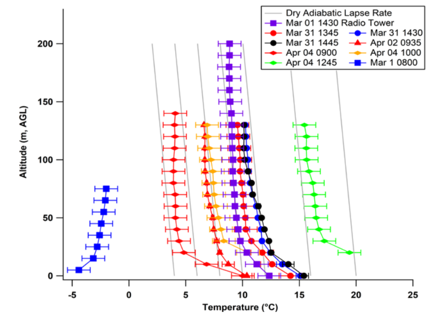
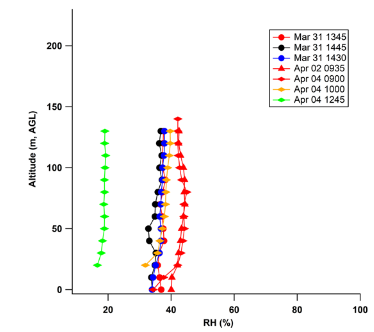


Figure 1: Flight tracks and measured data before averaging.

BME-280 Sensor Measurement	Accuracy
Temperature	±1°C
Humidity	±3% RH
Pressure	170 Pa (1%, 11 cm)







Temperatures changed rapidly from the surface to 30 m, where the air is most effected by surface heating. The dissolution of the evening boundary layer to a typical daily temperature profile is observed.

Flight Guidelines:

-No flights over people

-400 ft AGL (or building)

-Night Flights ok (equip.)

-Visual Line of Sight

->400 Feet with waiver

-Flights in controlled airspace > 400 ft with COA

Conclusions:

The UAS platform presented here allowed for initial testing of lower atmosphere sounding in the lower PBL. The VAT-Quad was able to resolve temperature and RH humidity profiles. The UAS was adequate for current payload size and power requirements. Limitations of the platform include: no performance under high winds, battery life in cold weather, time response of the sensors, poor radio link for much older quad-copter. This UAS worked well for frequent, simple profiles, and was useful for teaching atmospheric temperature profiles and inversions for undergraduates.