



# Particulate Matter distribution and formation by size from 0.3 microns to 10 microns during Utah winter inversion events.



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## Introduction & Background

Urban areas in mountain basins often suffer from pollution problems. This is especially true in winter when high pressure atmospheric ridging, calm winds, and snow on the ground can result in a persistent cold air pool (PCAP) forming in the basin. This is what is commonly known as a winter inversion. The warm air aloft caps a pool of colder air in which fine particulates can form as a result of sunlight driven photochemistry acting on a mix of both natural and anthropogenic precursor compounds. The data reported in this poster is part of two large studies completed during the winters of 2016 and 2017. In 2016 measurements were made throughout the day, in 2017 we concentrated on the morning to observe the transition from nighttime to daytime and the start of the daily photochemistry happening in our air.

Our contribution to the larger studies involved an airborne set of sensors that were flown repeatedly in one location. Over 120 flights were completed with multiple sensor systems including a standard ozonesonde, a six-channel particle counter, a custom designed "AtmoSniffer" and automated cameras. These measurements are unique in that they provide a vertical column from ground level to 150 m (500 ft) above ground level (AGL) giving both a spatial and temporal set of measurements of the evolution of PM before, during, and after a PCAP event. Lidar measurements by the University of Utah measured the cap of the inversion at about 400 to 600 meters AGL. Thus we were able to measure approximately the bottom quarter-to-third of the inversion layer.



Figure 1. The tethered balloon, known as an aerostat, has a wind stabilizing wing (orange). The system was repeatedly winched up and down over 120 times.

## Winter 2016, SLC

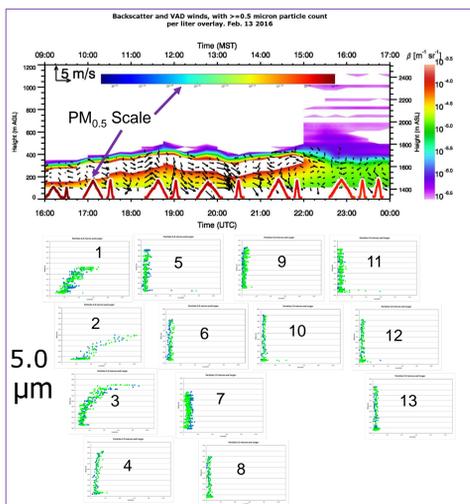


Figure 2. This is typical of particulates during the middle of the PCAP event. The lidar data at the top were taken at UDAQ's Hawthorne site 6.34 km north of the WSU aerostat operations. Notice that the PM altitude dependence is strong in the morning then becomes uniform. The PM formation starts at higher altitudes first. The numbers in the lower graphs are aerostat flight numbers which correspond to the small inverted "V" shapes superimposed on the lidar data. The "V" plots show 0.5 μm particulate counts vs. altitude and time.

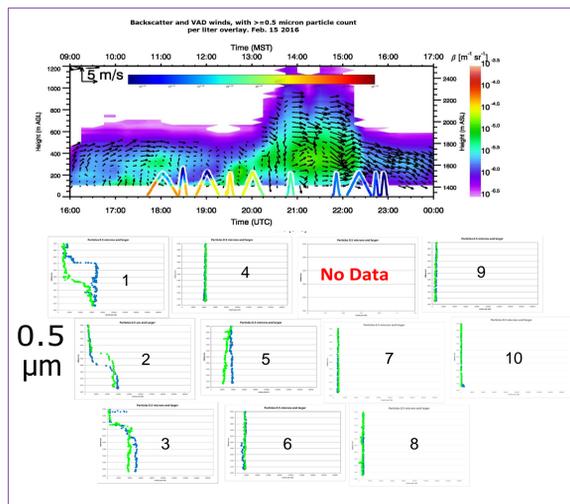
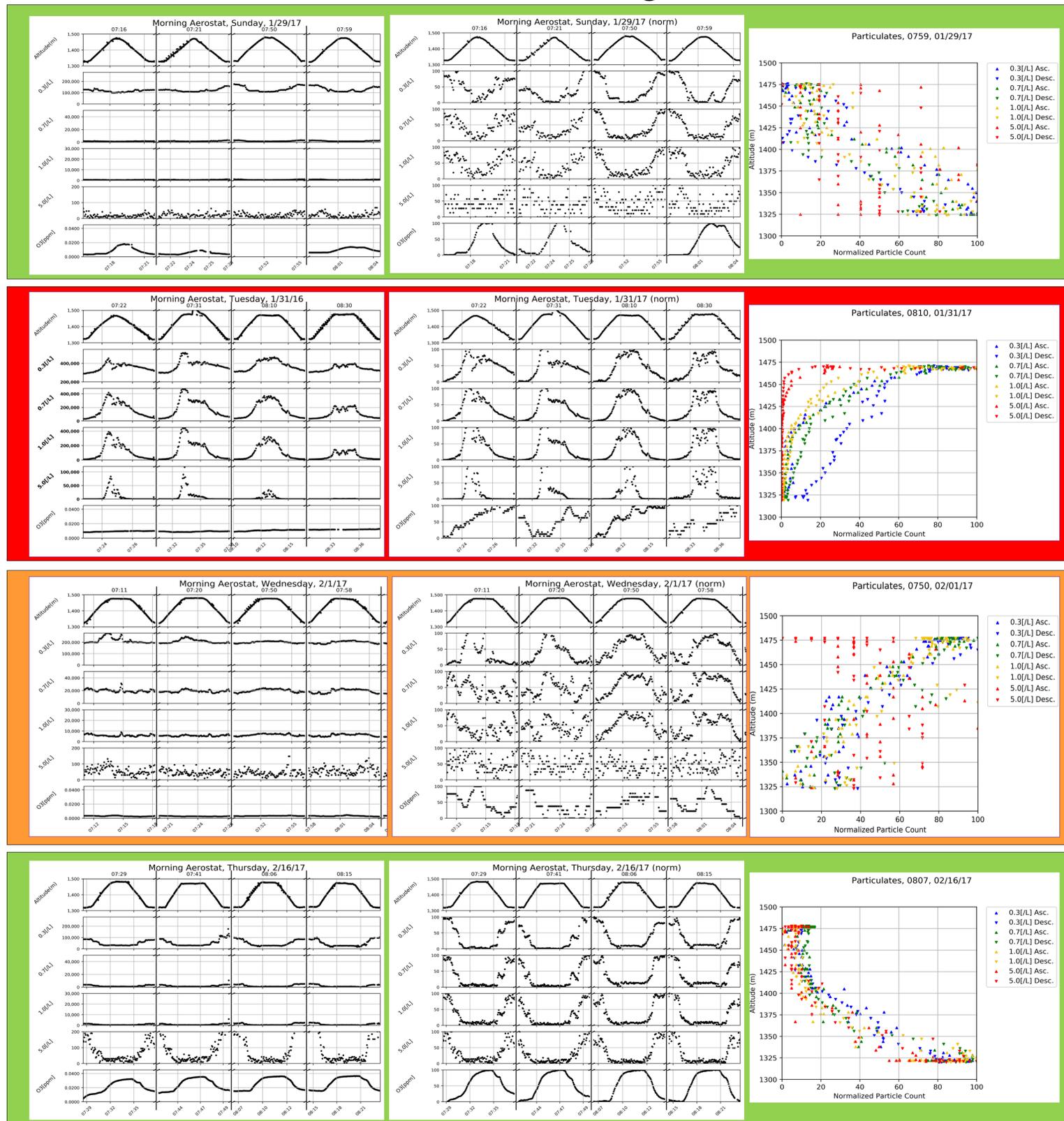


Figure 3. The PCAP was mixing out on the morning of Feb. 15, 2016. Notice the strong altitude dependence of PM during mix out with PM clearing out first at higher altitudes. Once the inversion had mixed out by about 20:30 UTC the PM lost its altitude dependence. All 2016 data were taken after sunrise. The general pattern was to have various layers and altitude dependence early in the morning then quickly becoming uniform in distribution. The initial build up at the start of the inversion was slow enough that the air was stable and uniform. The "V" plots superimposed on the lidar data show 0.5 μm particulate counts vs. altitude and time.

### Acknowledgements:

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## Winter 2017, Ogden



Figures 4. One goal of the Utah Winter Fine Particulate Study (UWFPS) 2017 was to study the evolution of particulates and ozone from night to day. These plots show the evolution of the air column at sunrise before, during, and after an inversion event. The background color is the approximate air quality. Layers of PM were common, but the overall trend was that the particulates formed first at higher altitudes then spread downward. Outside of the inversions the higher air was generally cleaner.

## Conclusions

Outside of the winter inversions the particle counts were both low in number and fairly consistent in altitude distribution. During the inversion events PM grew in number during the day starting at higher altitudes with sunrise then becoming mostly uniform in altitude. Occasional layers formed of some particle sizes but not others. As the two inversions mixed out the PM distribution was size, time, and altitude dependent but with no obvious pattern.