

# Vertical Column Measurements of Ozone and Aerosols During UWFPS-2017

John E. Sohl, Jeffrey Page, Sheri Trbovich

Ryan Lawton, Michael Hess, Erik Hall, Michael Remley

Weber State University, Physics Dept.

July 27, 2017



**WEBER STATE**  
UNIVERSITY

College of Science



Met One, GT-526  
Particle Counter

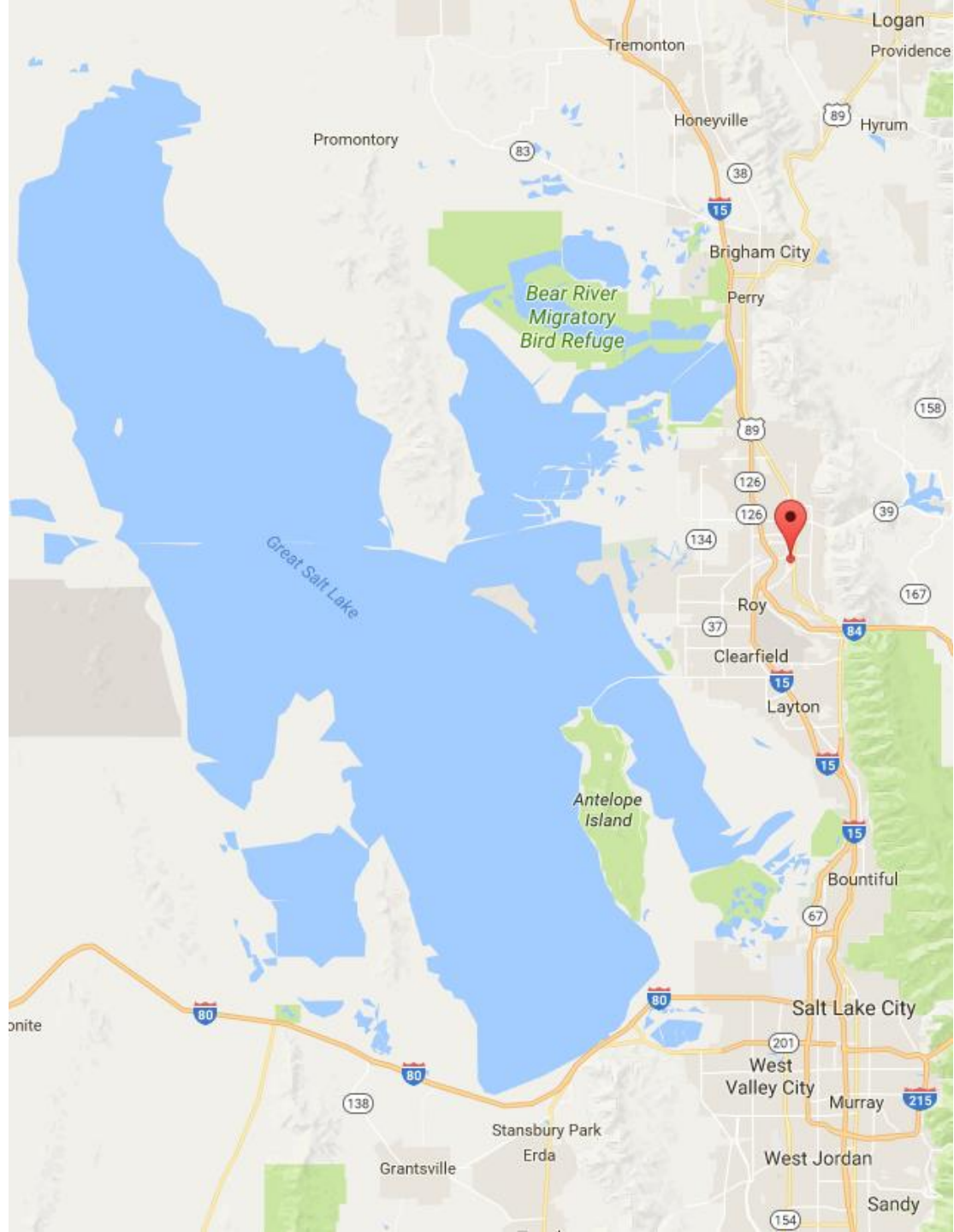
ECC Ozonesonde

AtmoSniffer or  
Cameras

UDAQ O2 Station

Frozen Students





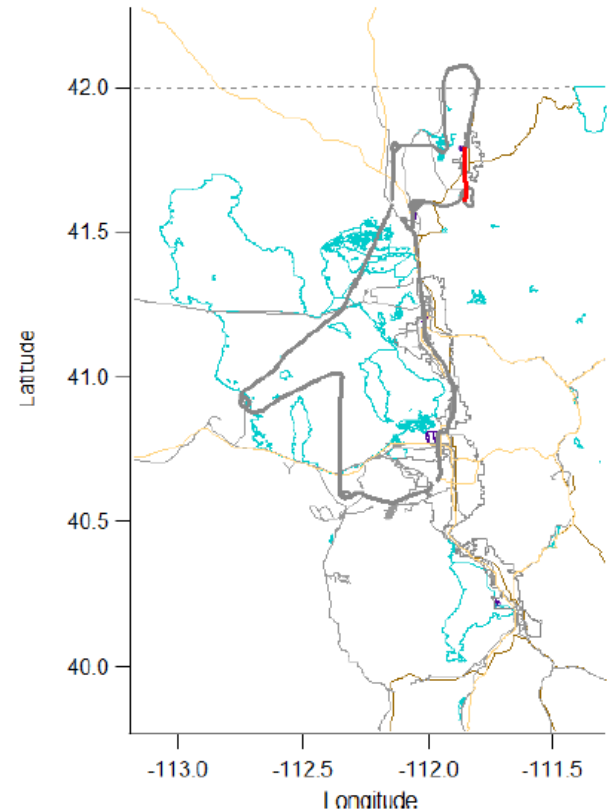
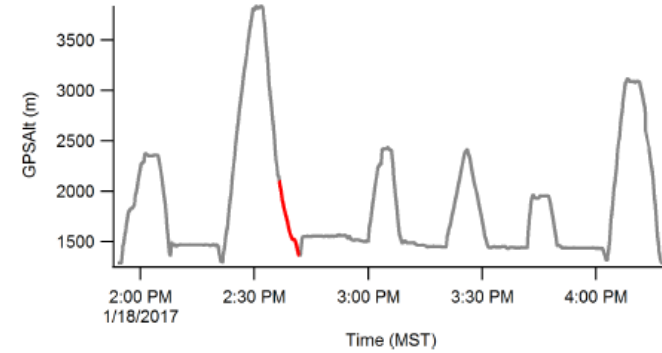
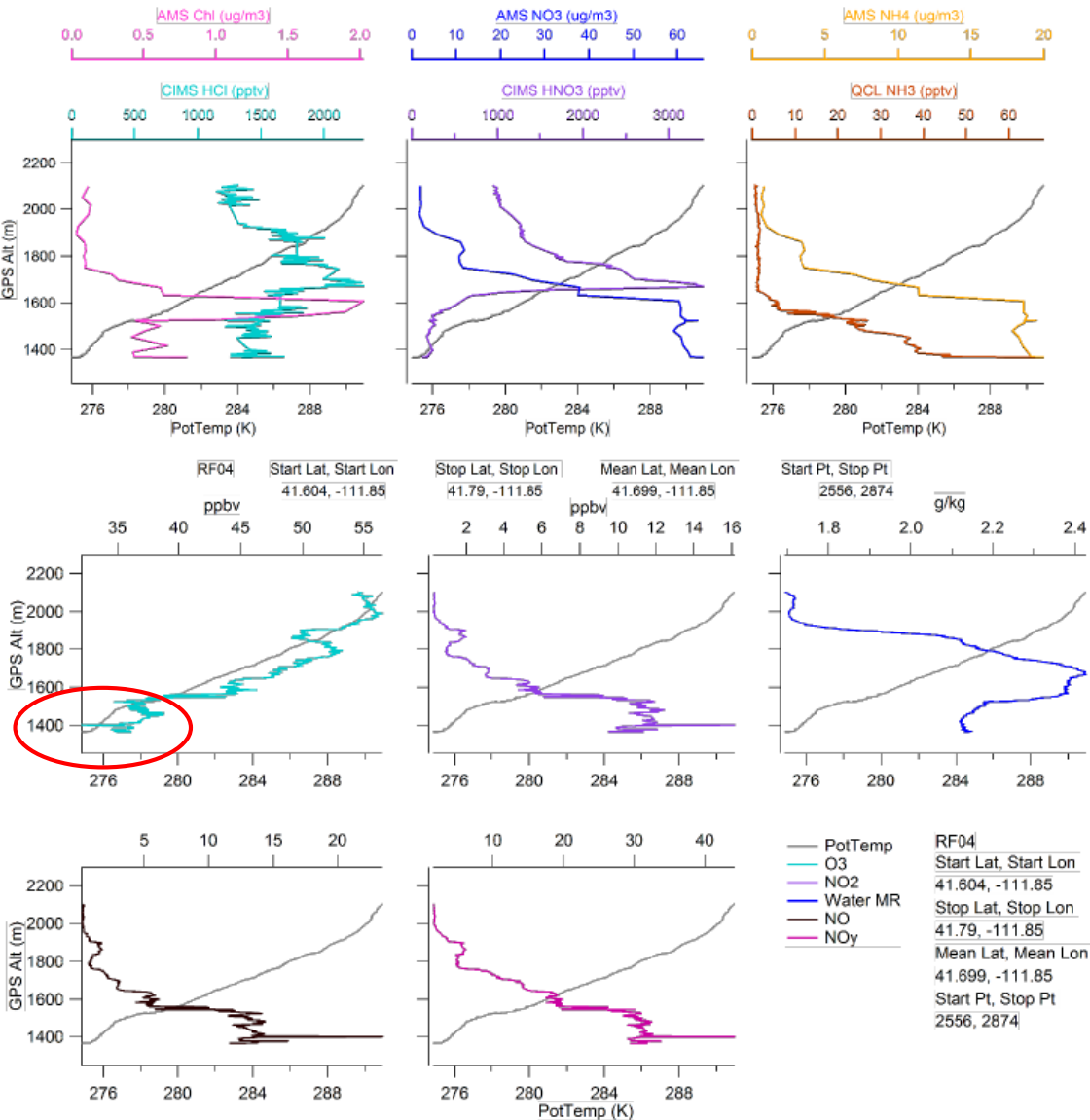


# UDAQ Ogden 2 site and twin otter missed approach.

Aerial View, Wide view showing relative location to the OGD runway 21:



WSU overlap with twin otter data. These are Cache Valley data from 1/18/2017 presented by Alessandro Franchin.



# 14 Measurement Operational Periods (114 flights) with Approximate PM Counts

First flights: data are good, but incomplete.

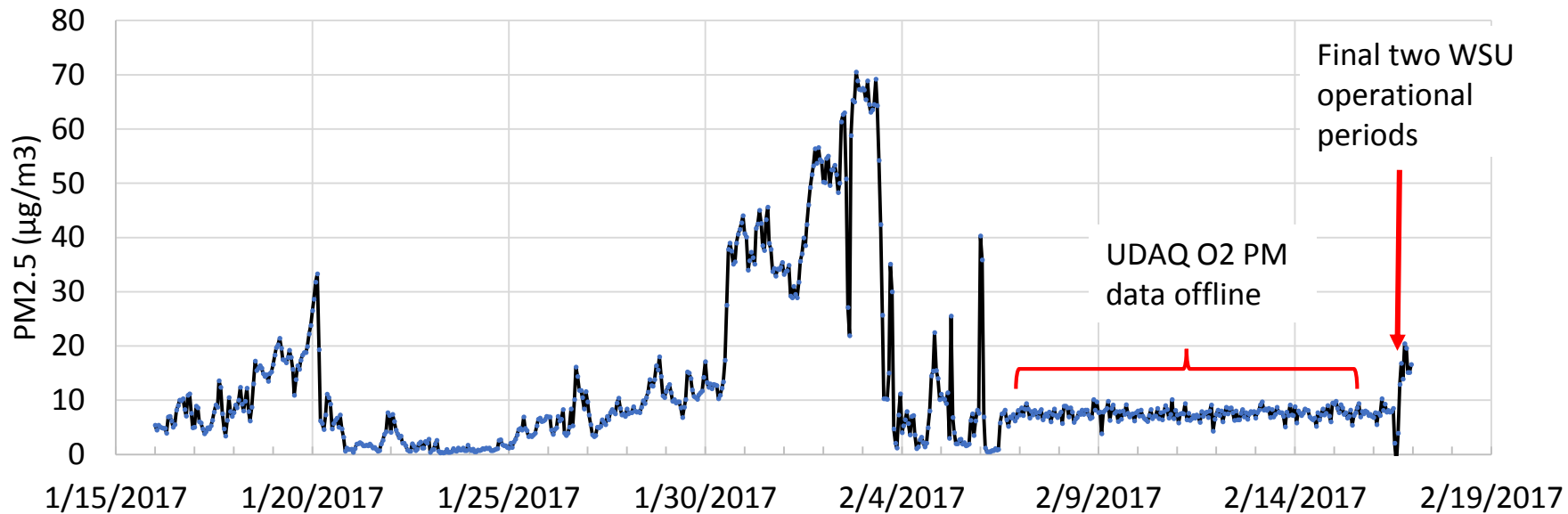
Day	Sunrise	Afternoon	Sunset	>0.3 $\mu$ m PM
Friday, 1/27	8:39 – 9:08	13:59 – 14:38	17:11 – 18:06	~75k/L → ~110k/L
Saturday, 1/28	8:21 – 9:29	13:53 – 14:26	16:54 – 18:05	~120k/L → ~200k/L
Sunday, 1/29	7:15 – 9:35			~125k/L
Monday, 1/30	7:15 – 8:51			~250k/L
Tuesday, 1/31	7:22 – 9:00		16:54 – 18:16	<b>~400k/L → ~220k/L</b>
Wednesday, 2/1	7:11 – 8:36			~200k/L
Thursday, 2/2	7:20 – 8:41			~300k/L
Thursday, 2/16	7:15 – 10:07		17:05 – 18:36	~50k/L → ~75k/L

Ozonesonde ECC frozen, ran to the lab to get the backup unit.

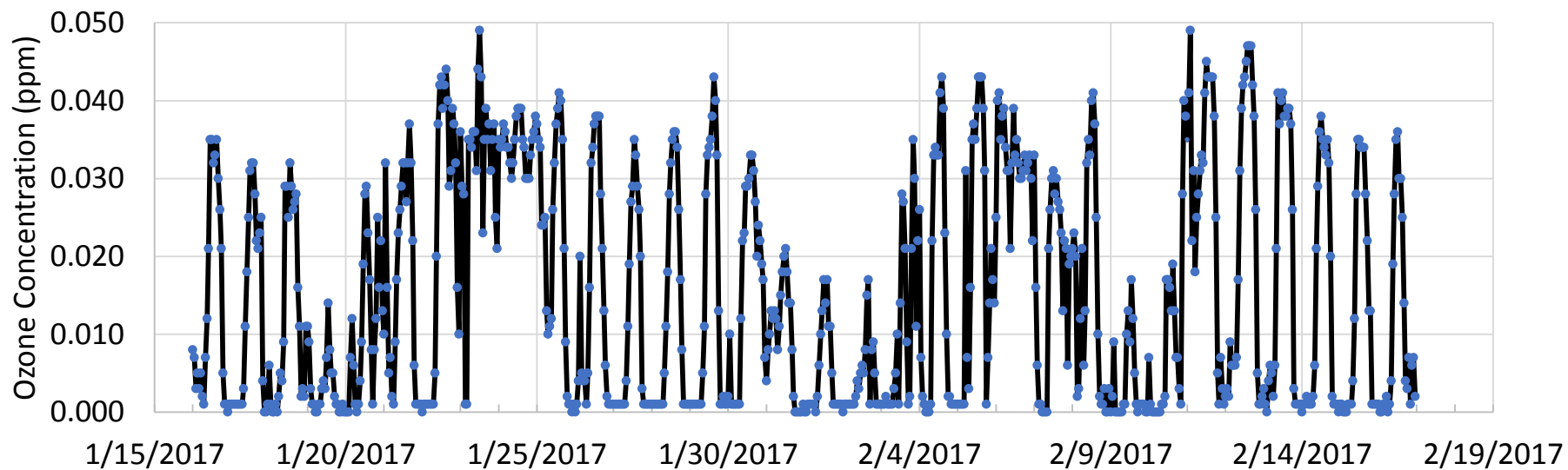


The complete UWFPS 2017 Operational Period.

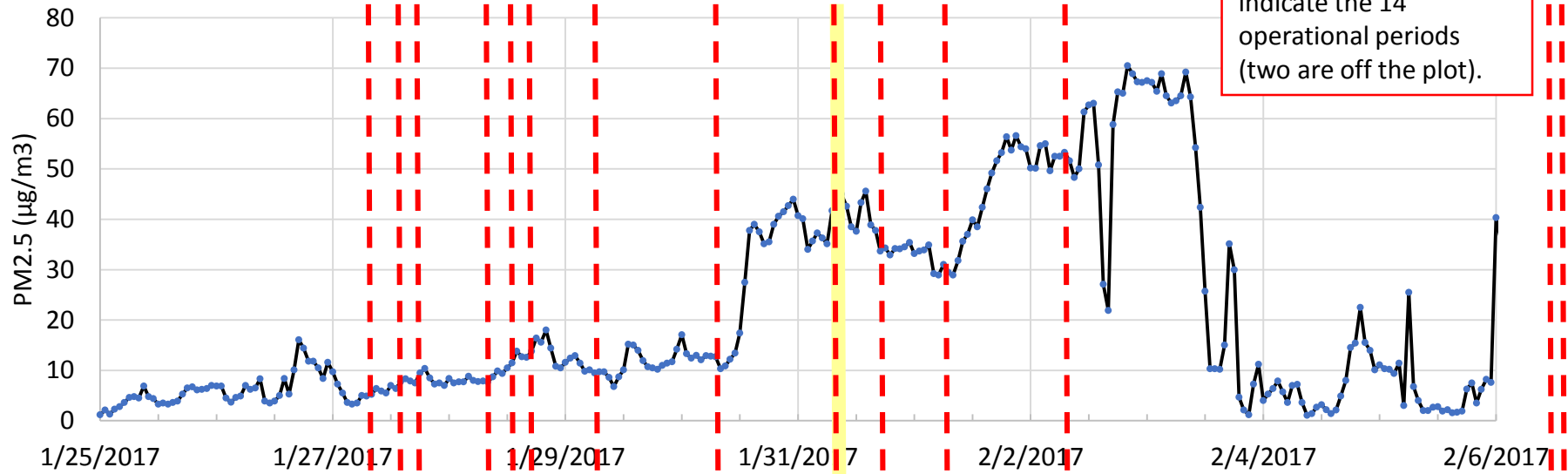
PM2.5 Mass Count, UDAQ Ogden O2 Station



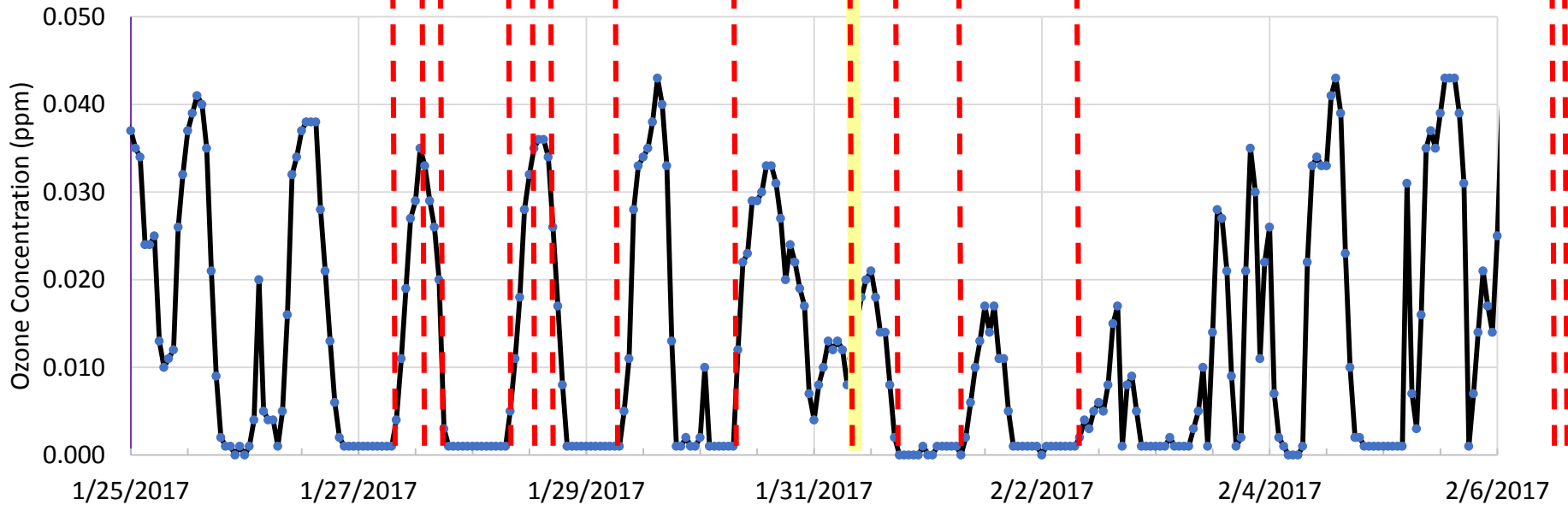
Hourly Ozone, UDAQ Ogden O2 Station



### Hourly PM2.5, UDAQ Ogden O2 Station



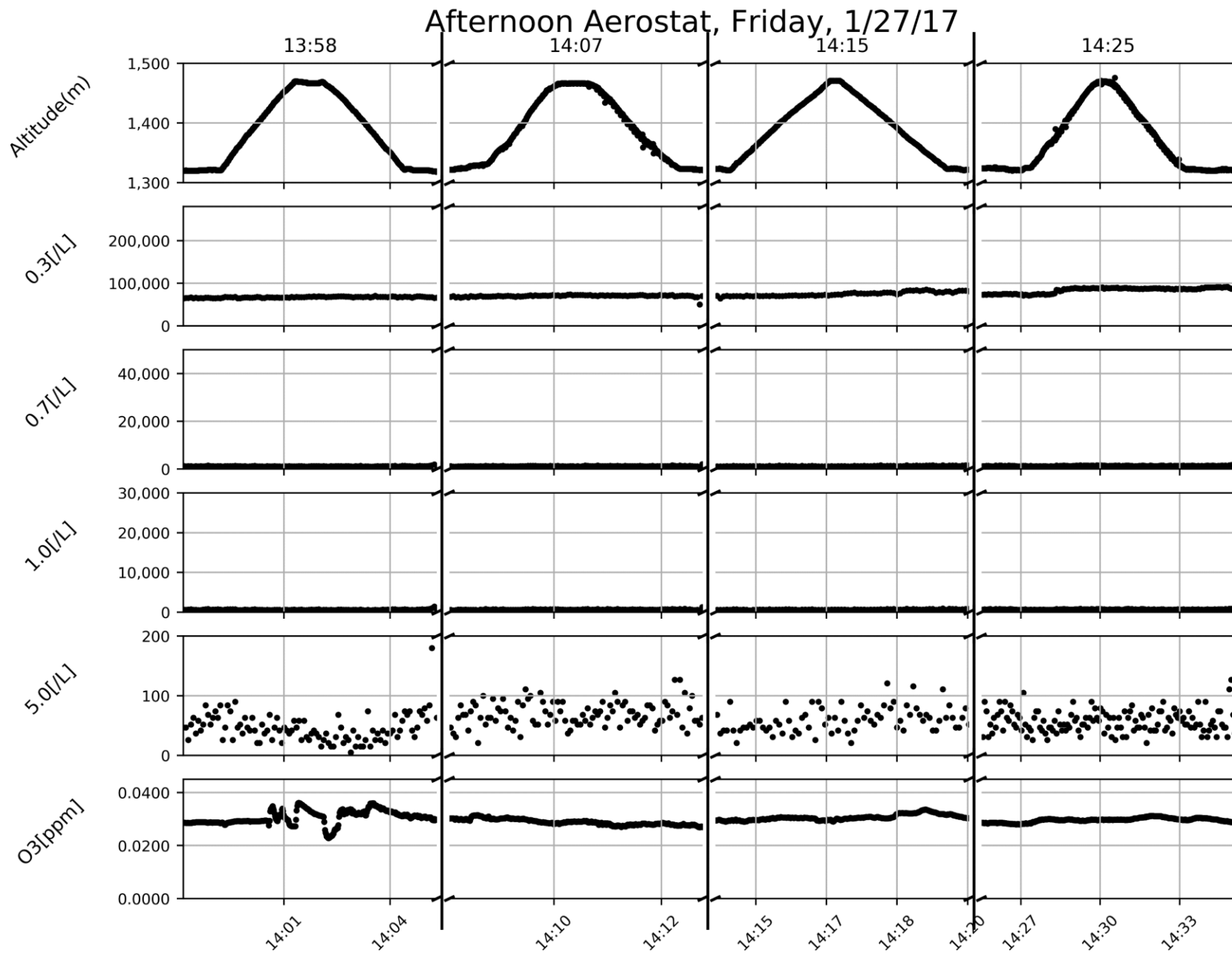
### Hourly Ozone, UDAQ Ogden O2 Station





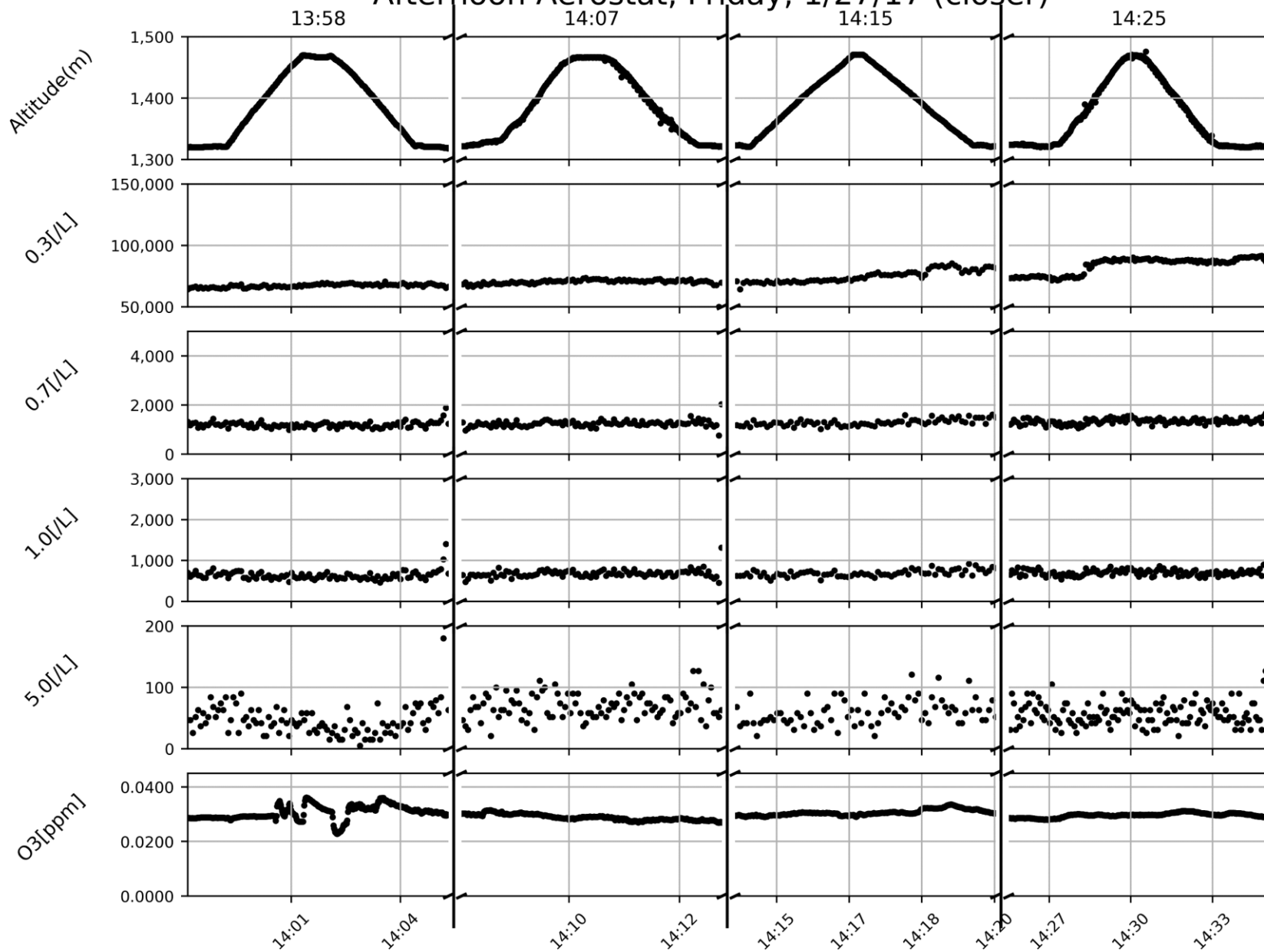
Afternoon, Pre-inversion

Uniform air columns with zero altitude dependence.

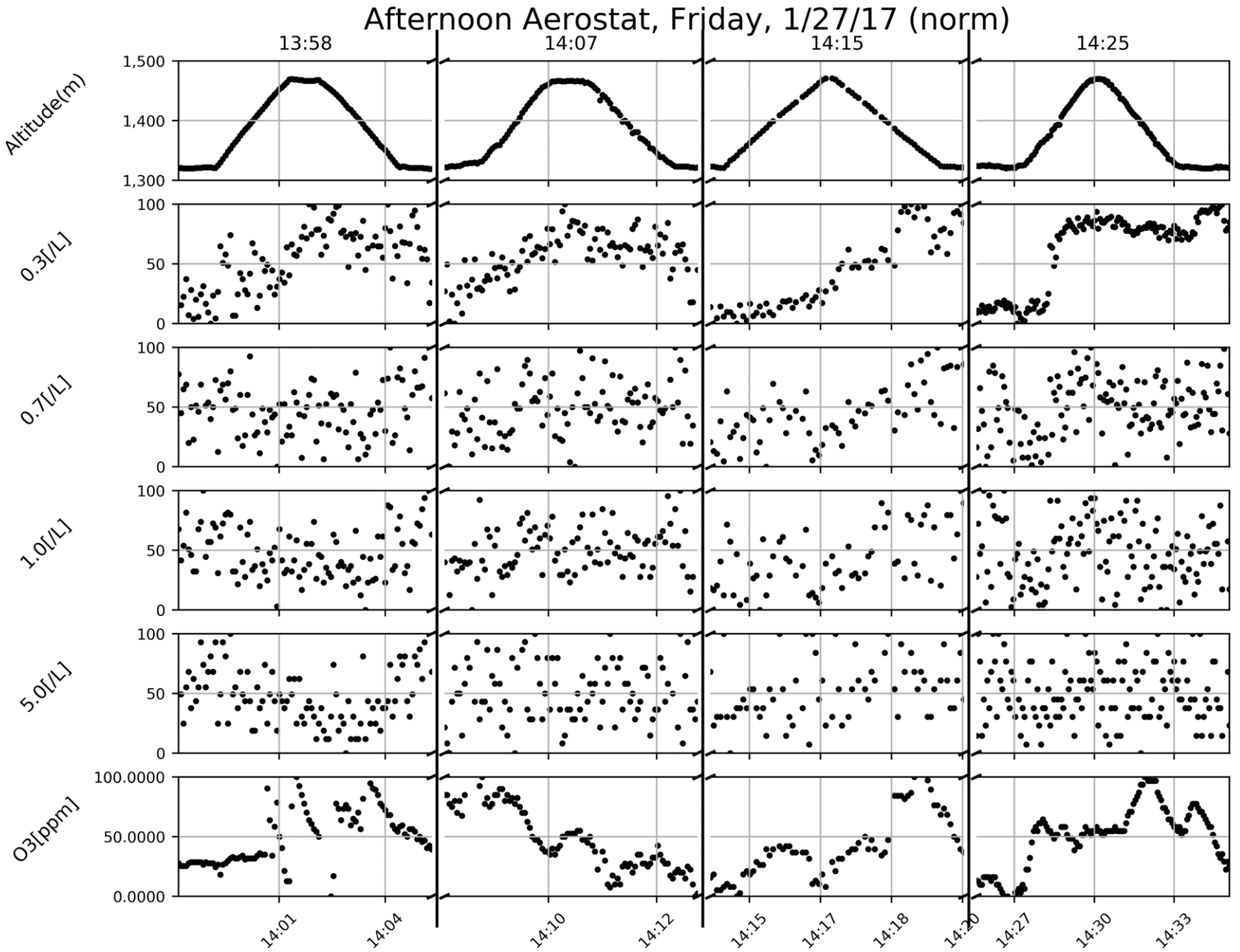


Zooming in the scale is showing some detail.

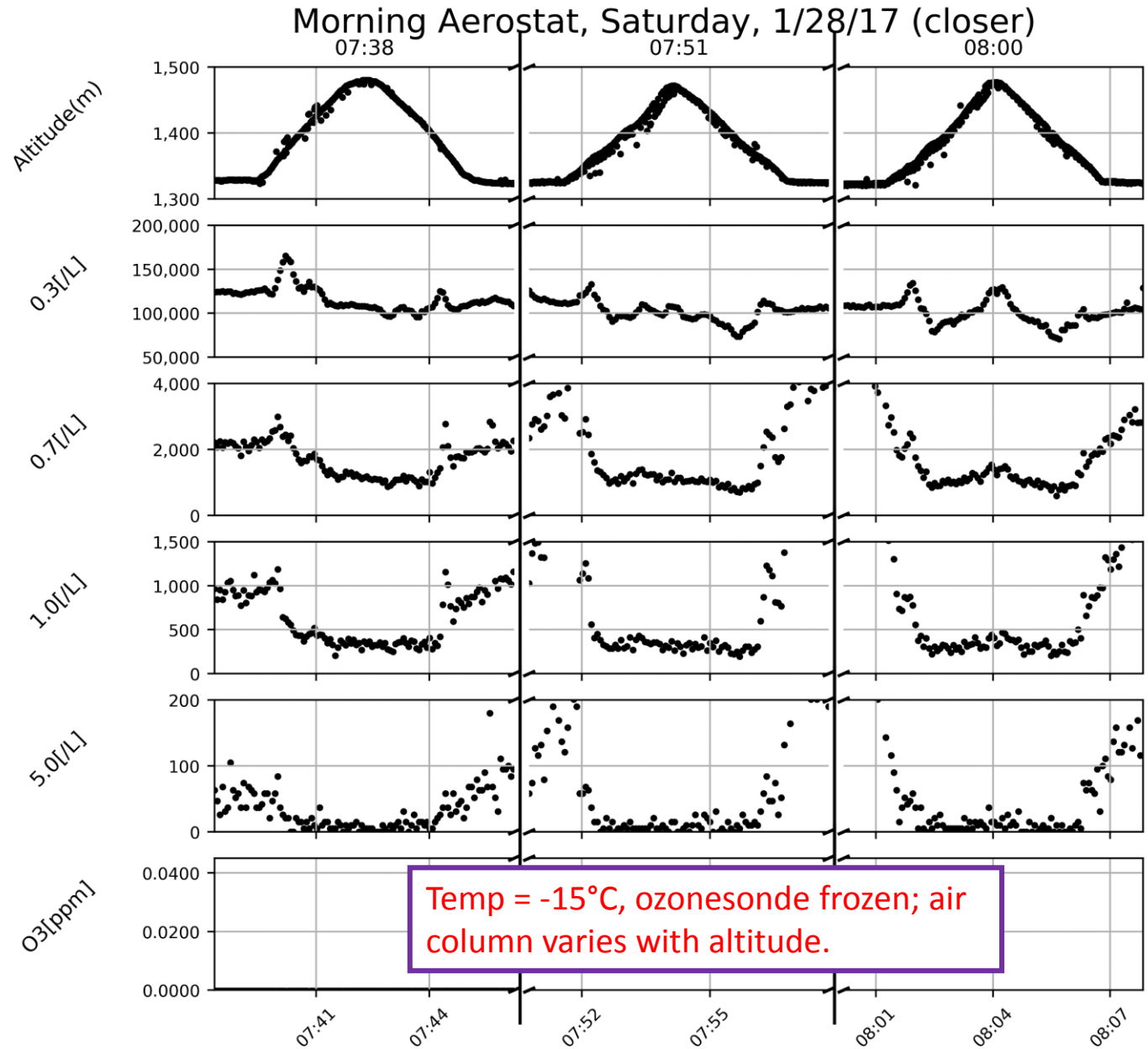
### Afternoon Aerostat, Friday, 1/27/17 (closer)



Normalizing the scale shows more detail.

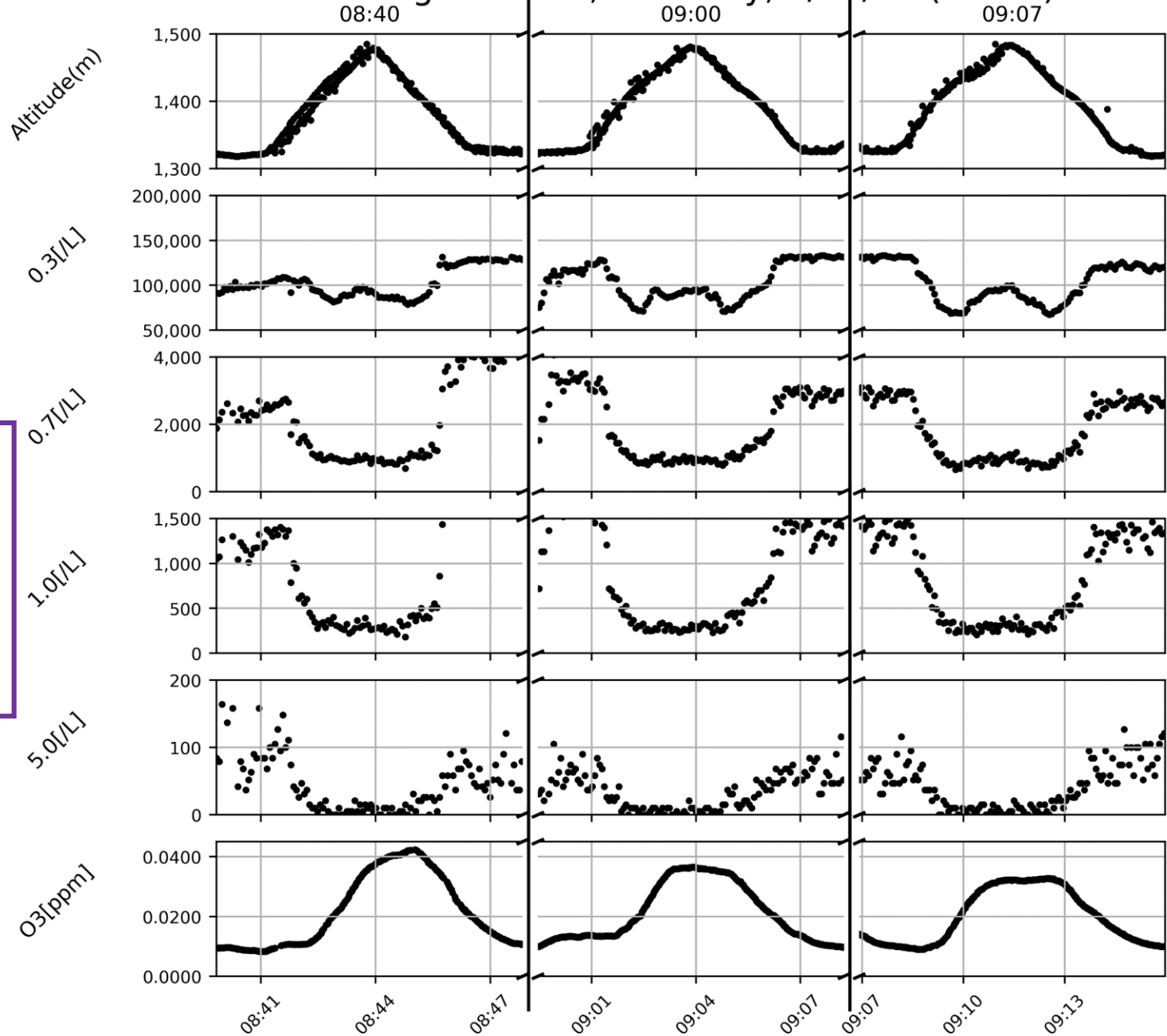


Next day. Still pre-inversion, but hints of building. Layers of particulates moving through.





# Morning Aerostat, Saturday, 1/28/17 (closer)

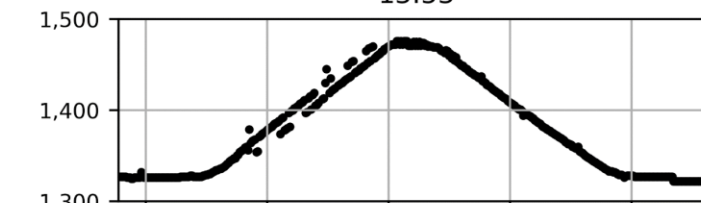


Backup ozonesonde online. Air column is unstable. Inverse relation with PM and O<sub>3</sub>.

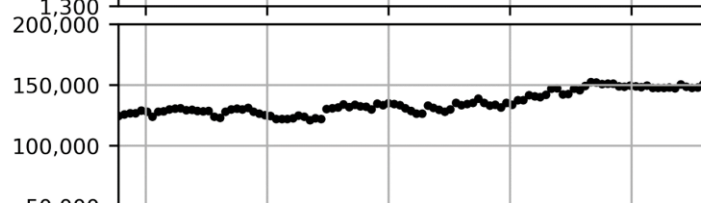
# Afternoon Aerostat, Saturday, 1/28/17 (closer)

13:53

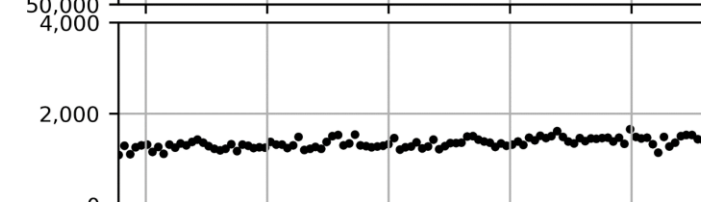
Altitude(m)



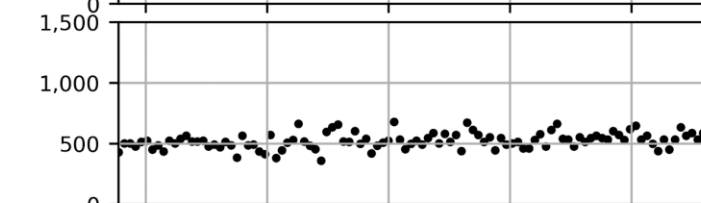
0.3[L/L]



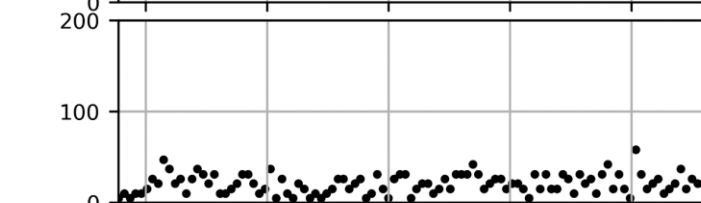
0.7[L/L]



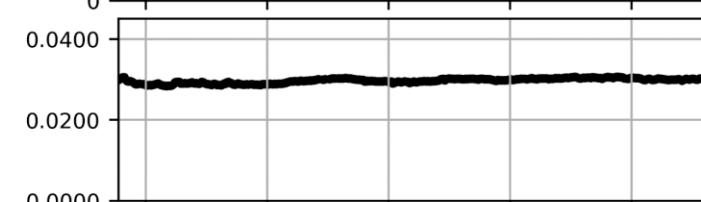
1.0[L/L]



5.0[L/L]



O3[ppm]



Pretty typical afternoon data set. No significant or repeatable variations with altitude.

13:54

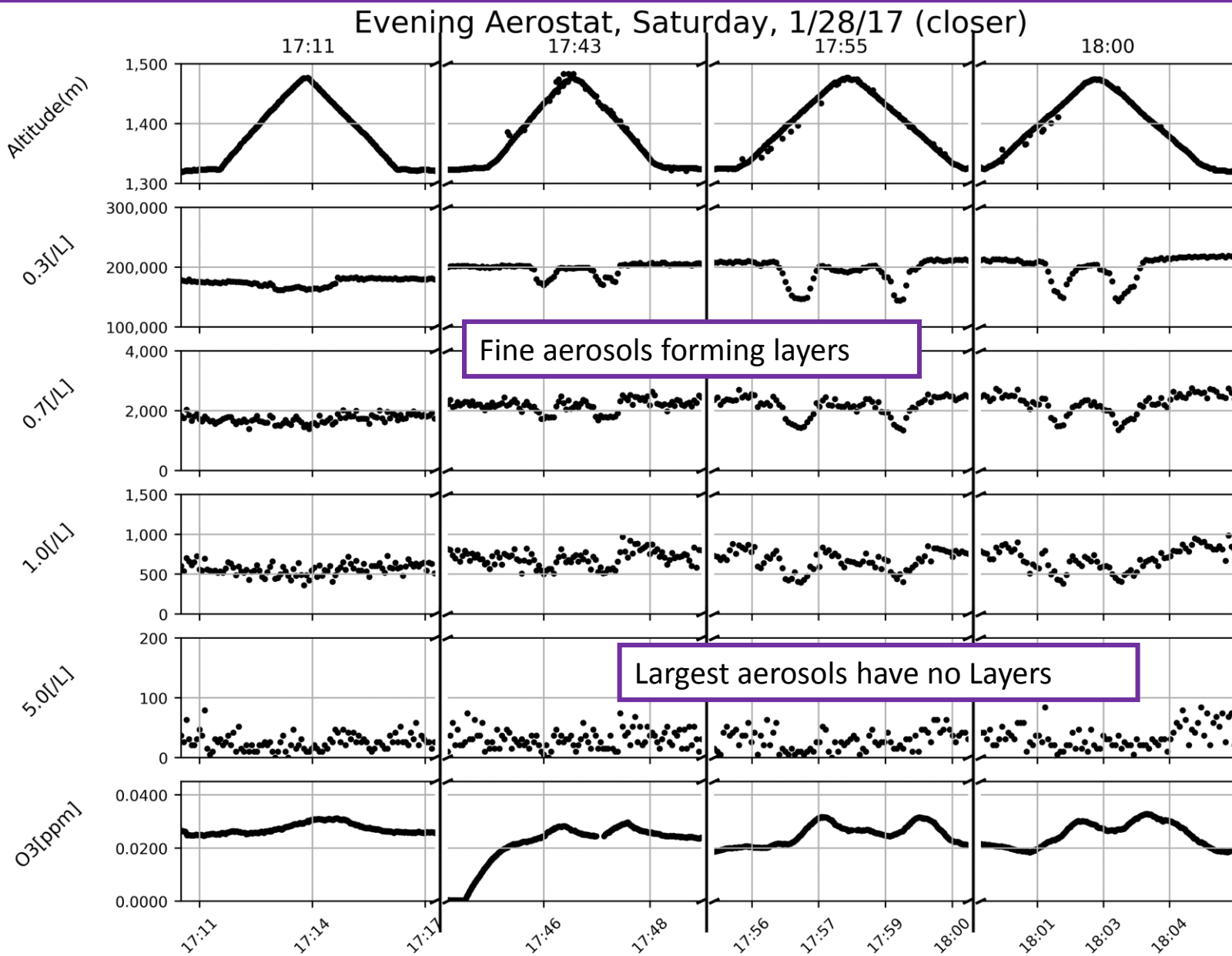
13:55

13:57

13:58

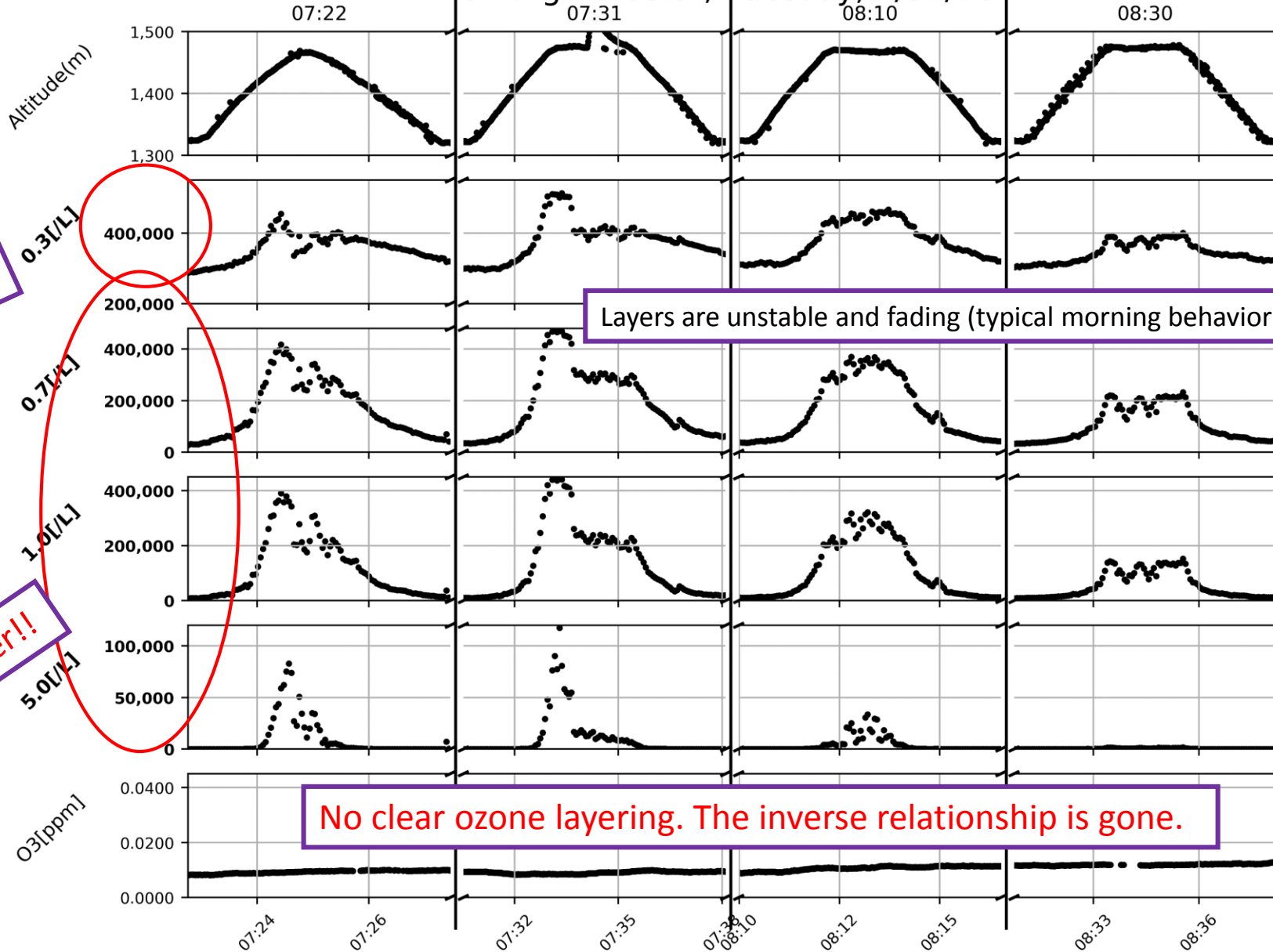
14:00

Typical evening non-inversion or weak inversion behavior. Inverse relation PM:O<sub>3</sub> with layers moving up and down.



The inversion is solidly in place.

### Morning Aerostat, Tuesday, 1/31/16



Slightly Higher

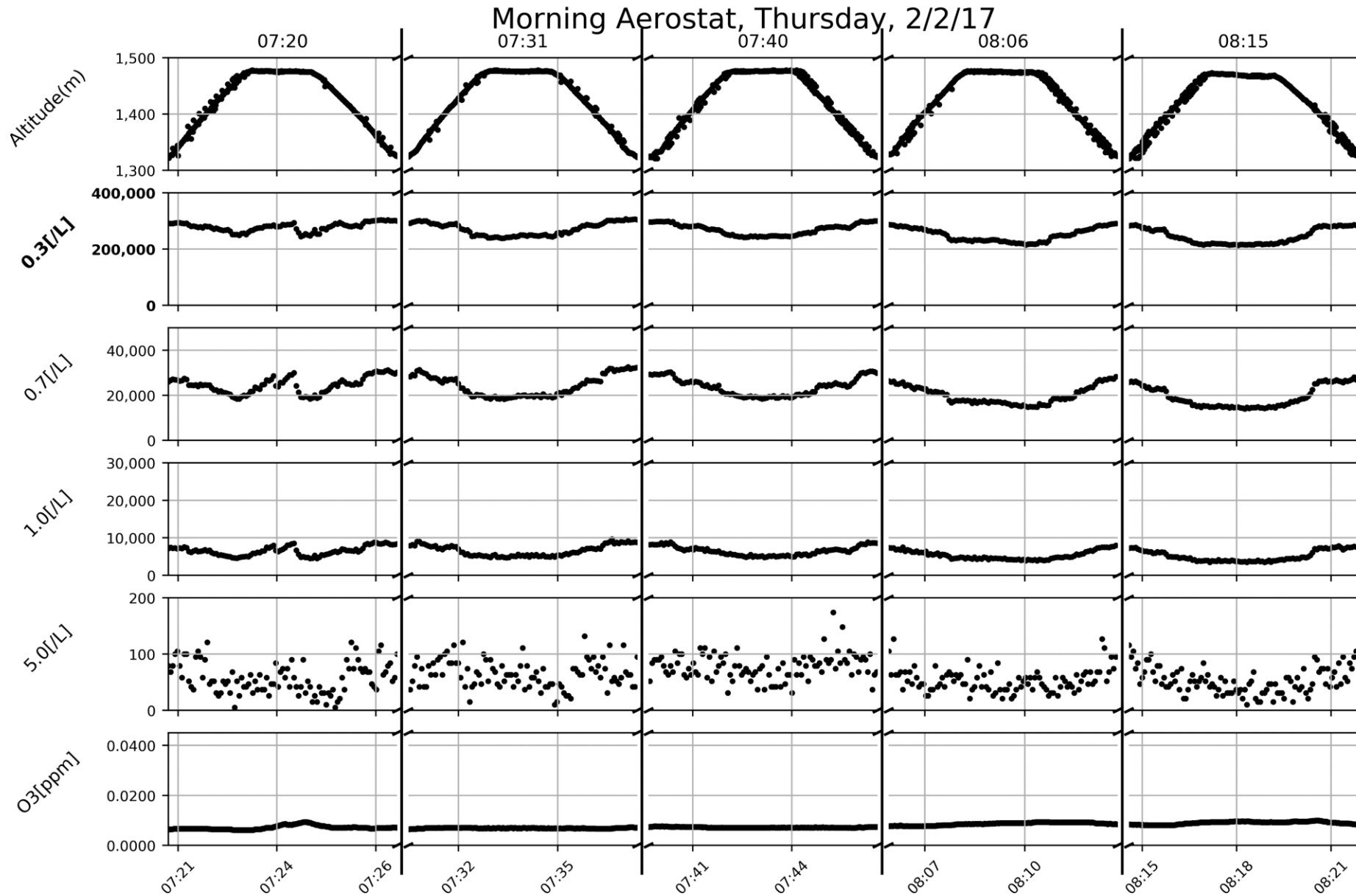
Layers are unstable and fading (typical morning behavior).

Higher!!

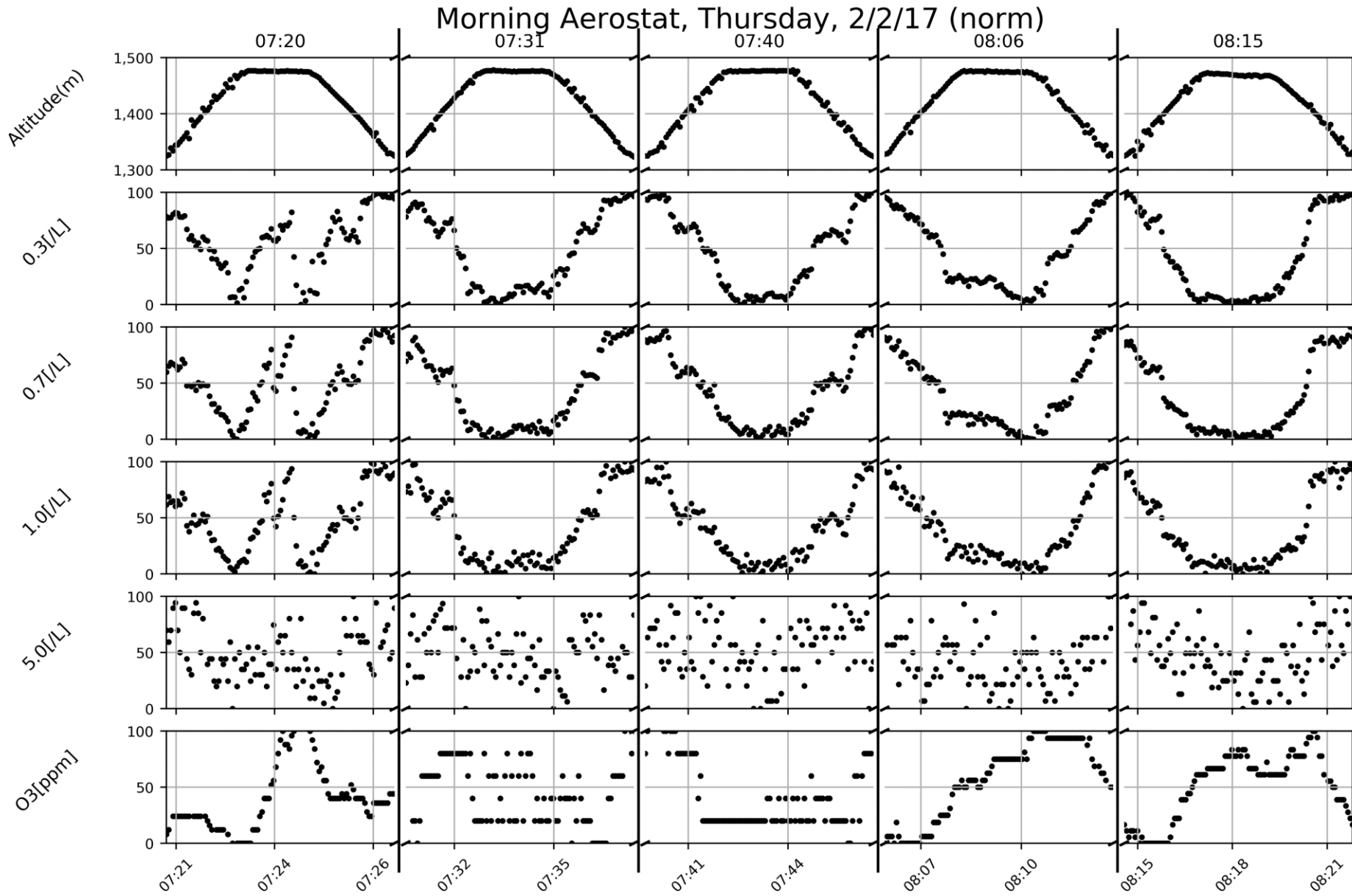
No clear ozone layering. The inverse relationship is gone.



Strongest inversion as measured by UDAQ Ogden O2 during operational periods. Note scales. Our finest PM is still elevated, larger PM has dropped. Layers are harder to see.

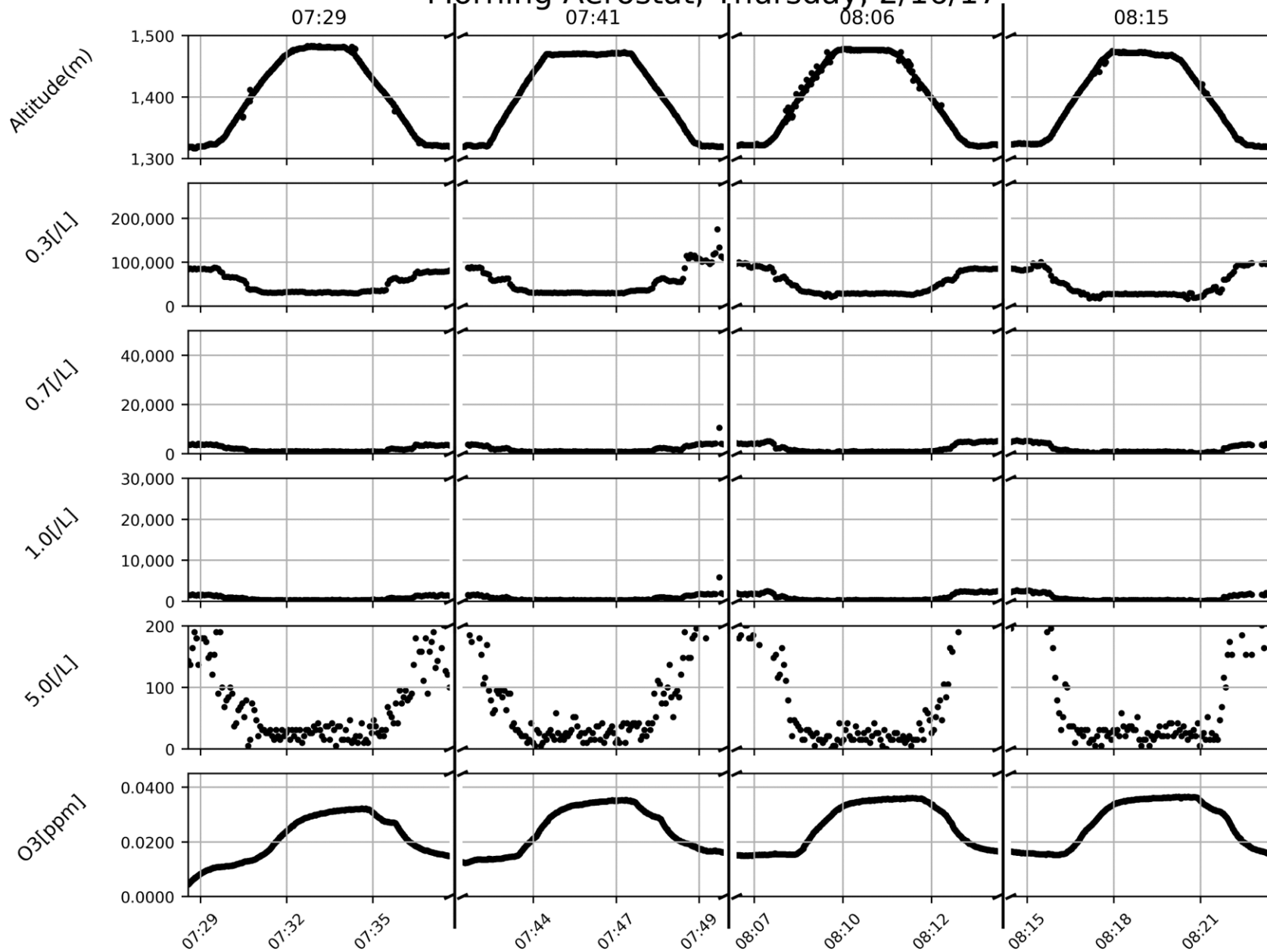


Normalizing the data can be deceiving, but does show layer detail better. Relationship of ozone to PM is not clear.



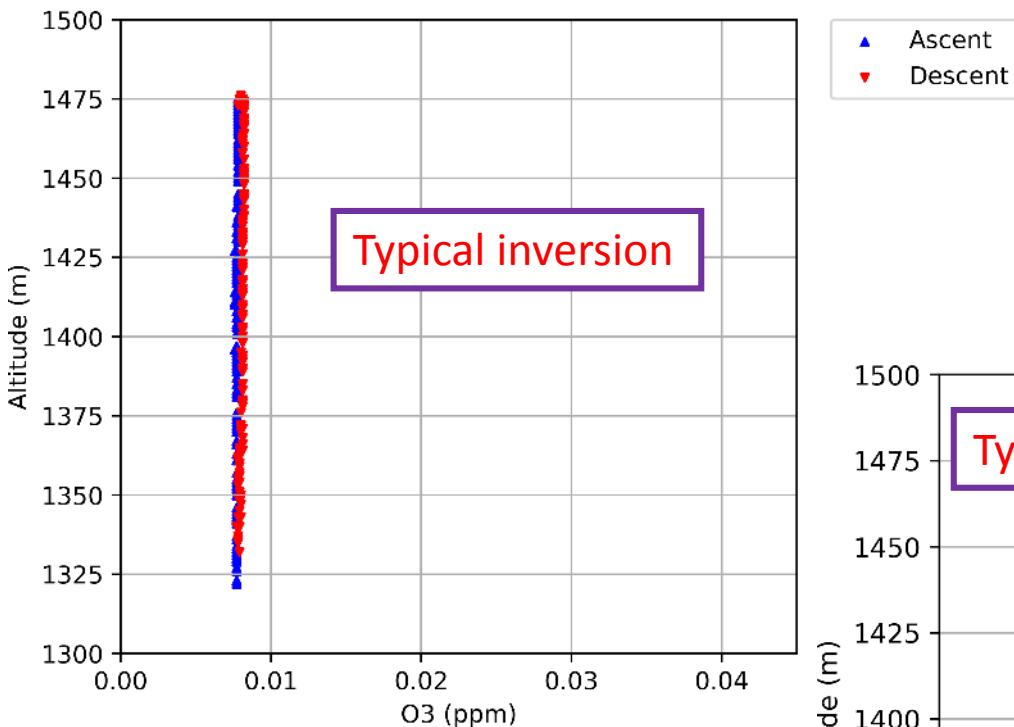
Typical post-inversion: More PM near ground, more ozone higher, inverse relation is back.

### Morning Aerostat, Thursday, 2/16/17



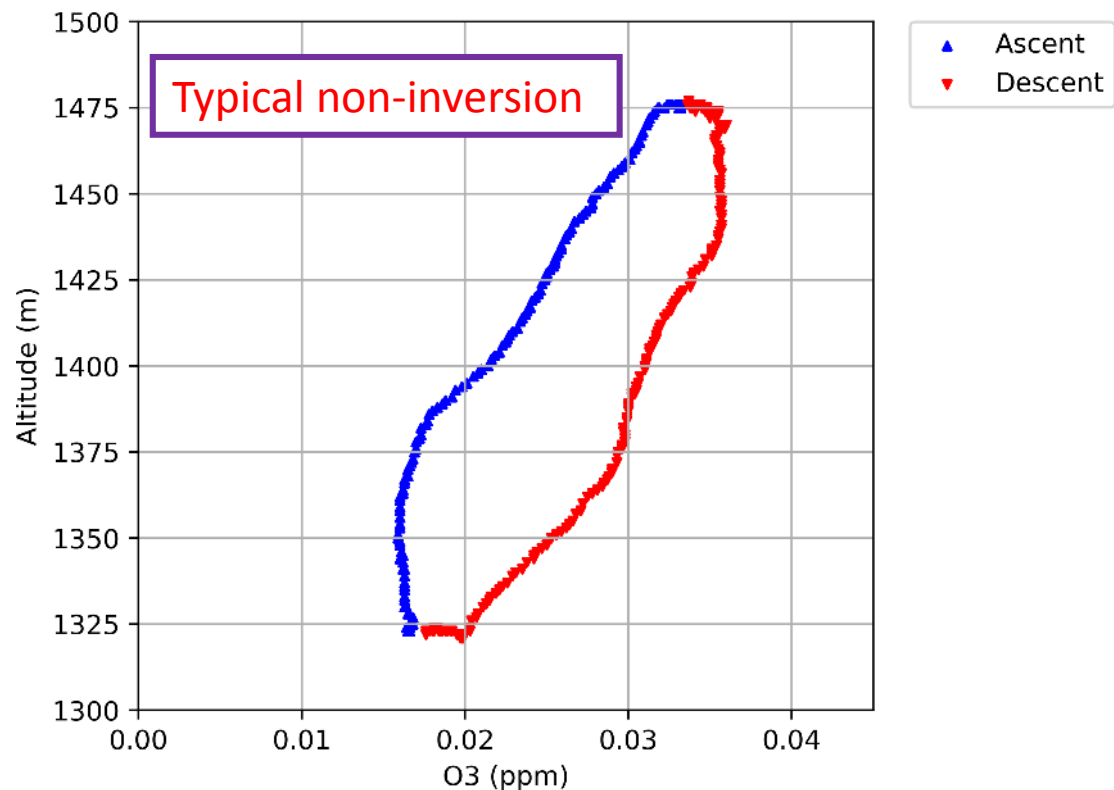
Looking at the data differently. Typical morning ozone columns.

O3[ppm], 0757, 02/02/17



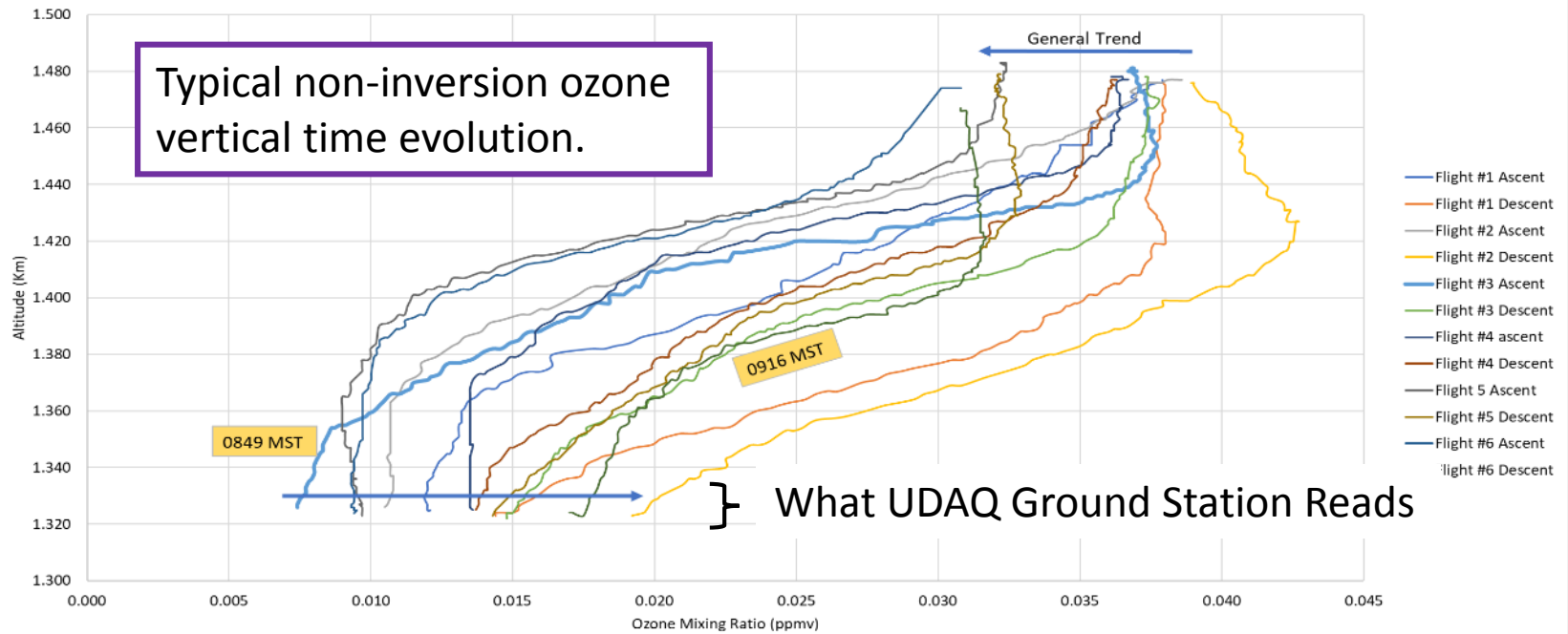
The ozonesonde has a 1.5 to 2 minute response time. Typical column flight time is ~7 minutes.

O3[ppm], 0759, 02/16/17

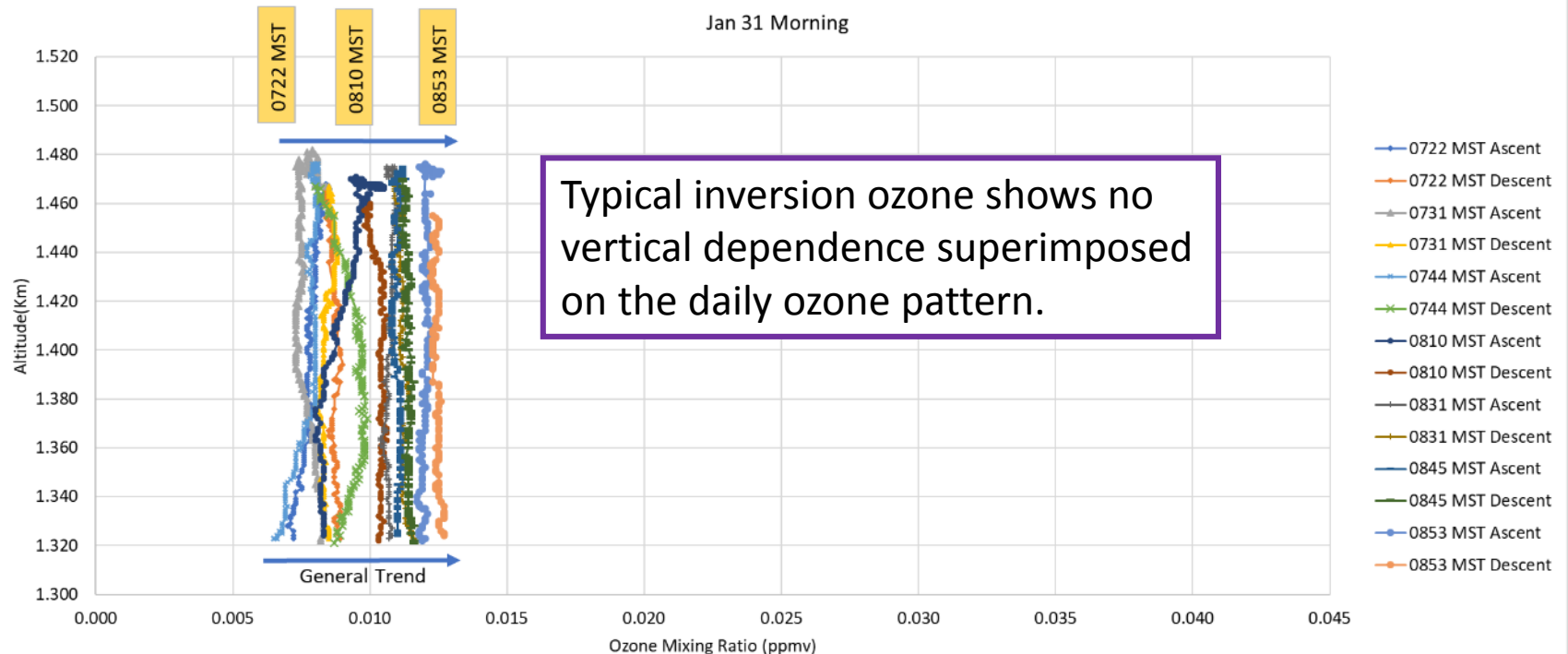




Jan 28 Morning



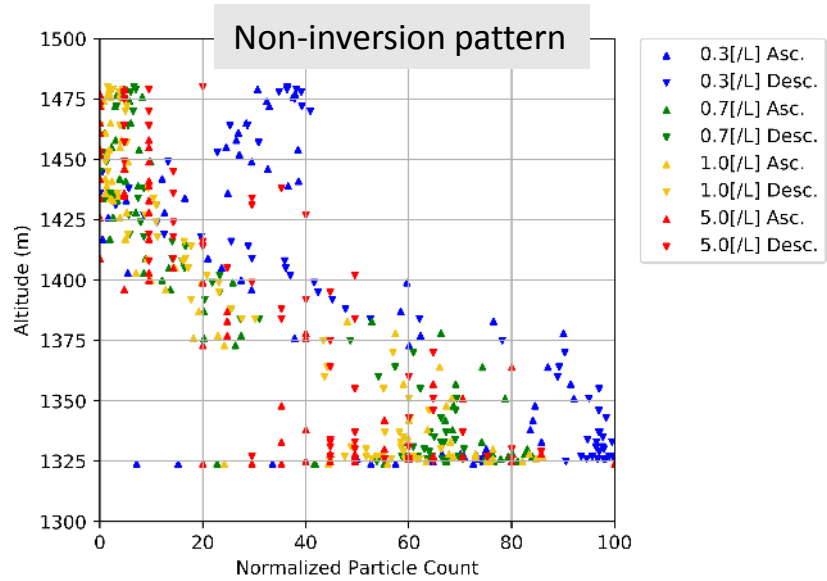
Jan 31 Morning



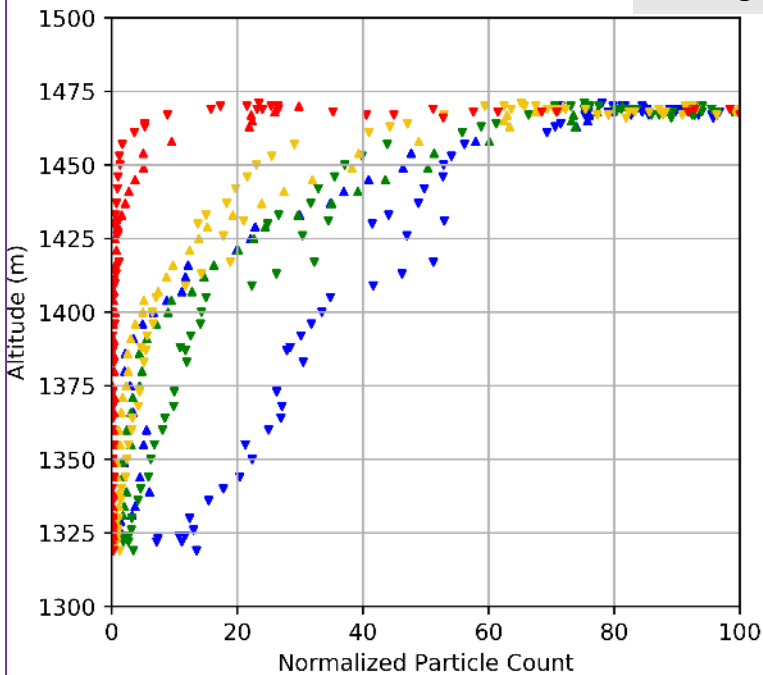
## Particulates:

Typical non-inversion pattern shows more PM near ground with occasional layers. (This one has a small layer of 0.3  $\mu\text{m}$  particles.)

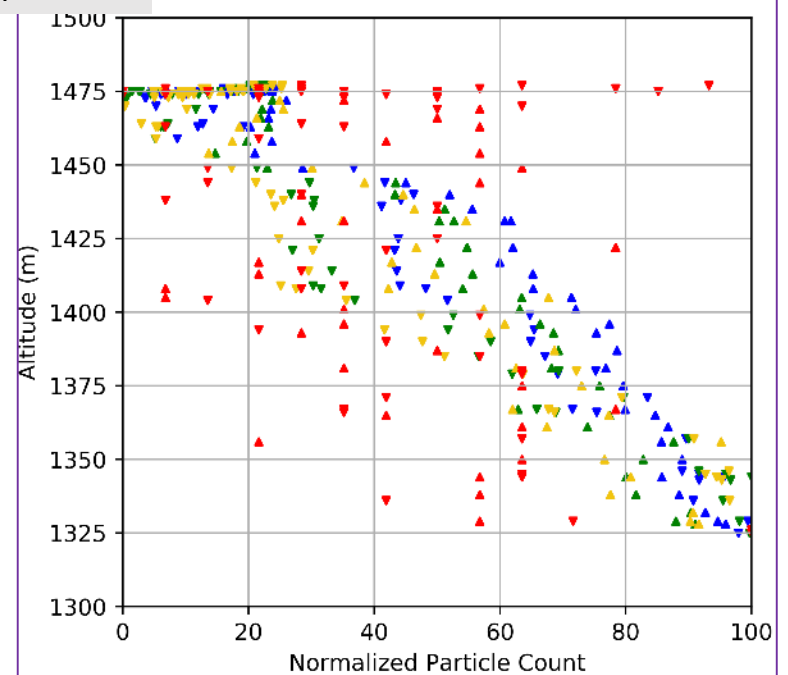
During inversion: either more PM with altitude or a weak non-inversion pattern.



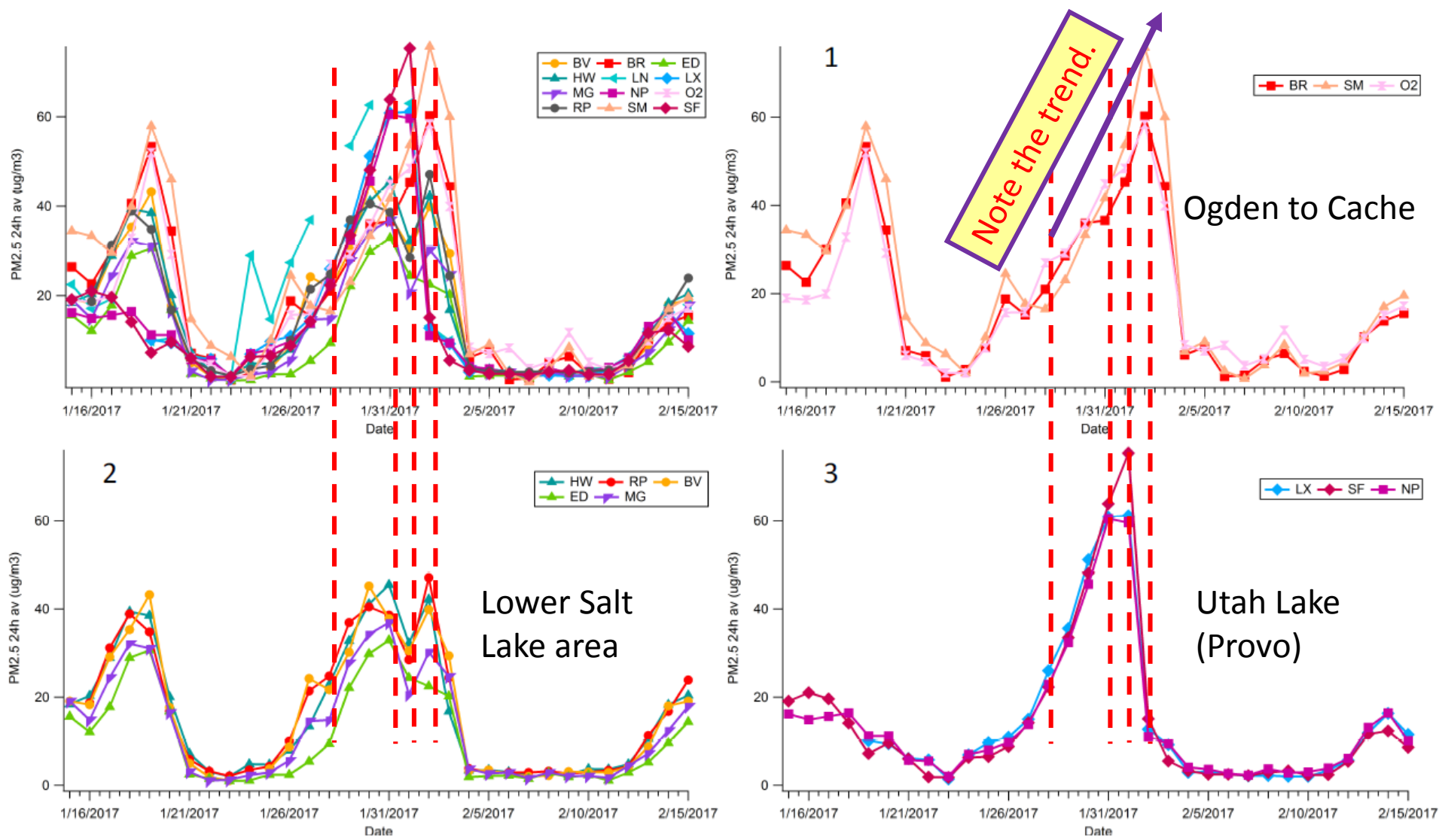
Particulates, 0810, 01/31/17



Particulates, 0806, 02/02/17

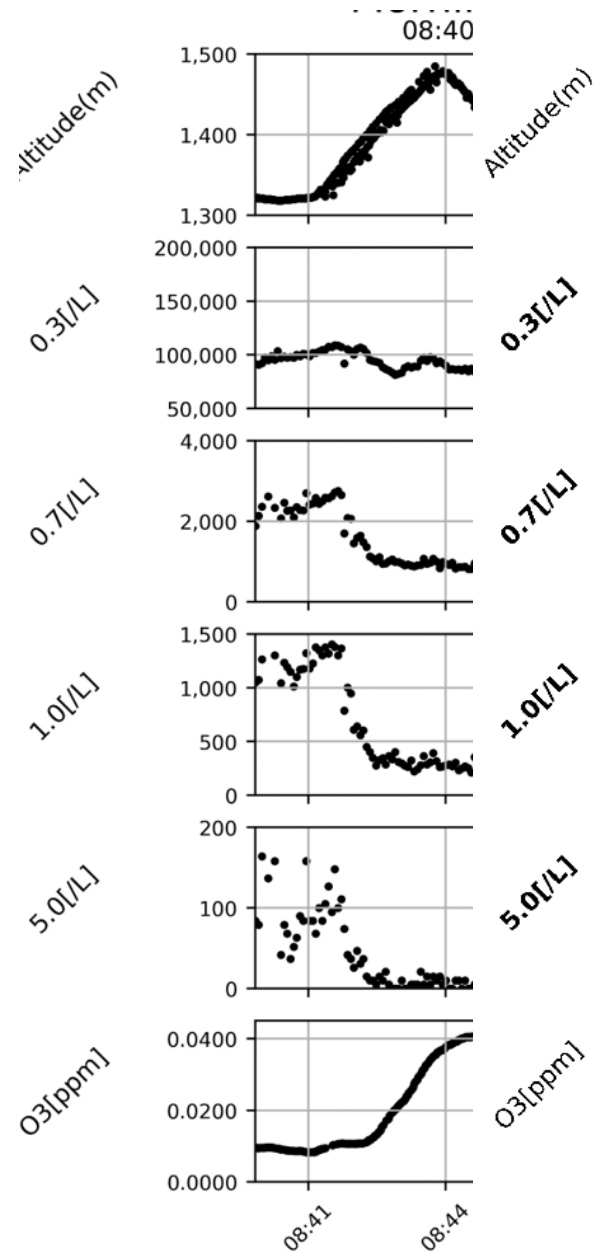


From Alessandro's presentation, there is a timing offset with location. We found an offset with time and particle size (next slide).



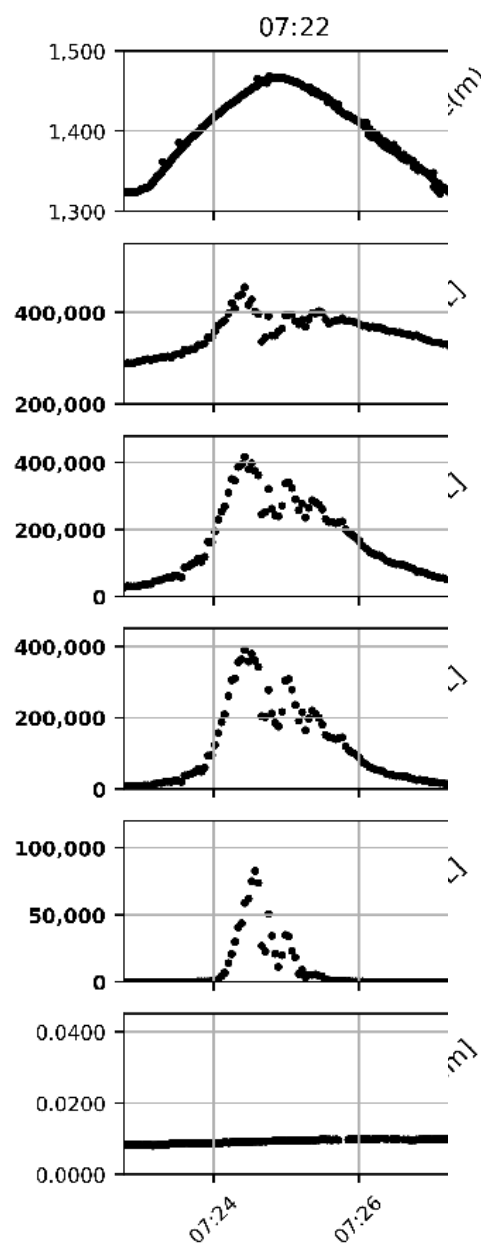
Pre-inversion

1/28/2017

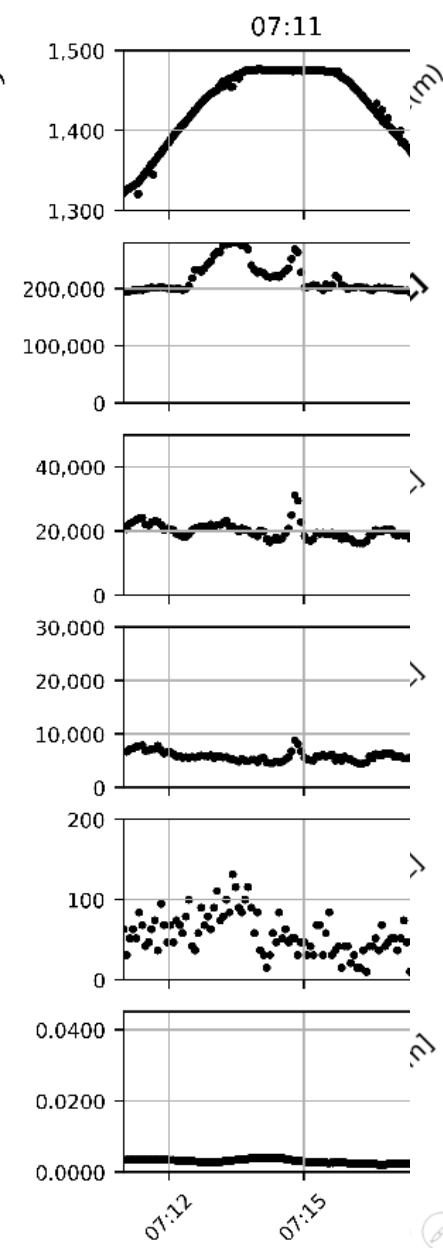


Inversion building up as per ground station (O2).

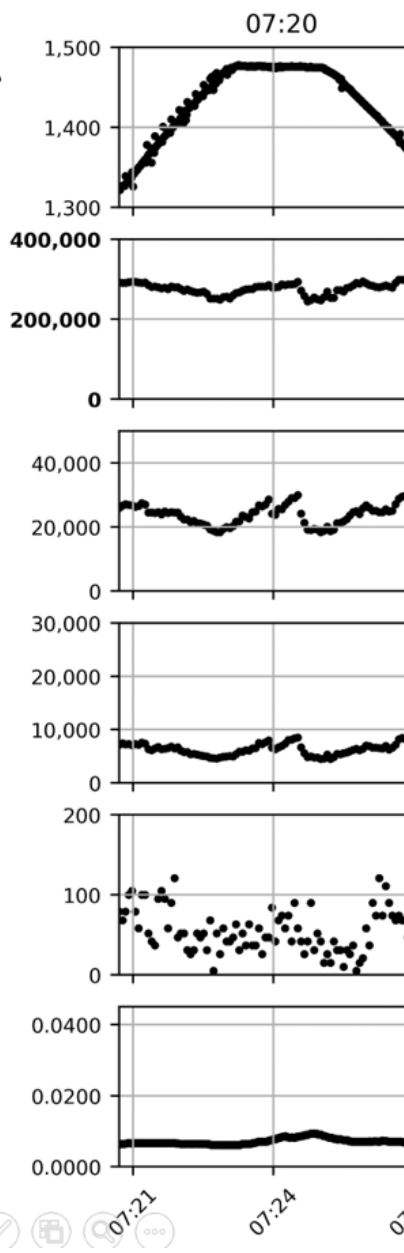
1/31/2017



2/1/2017

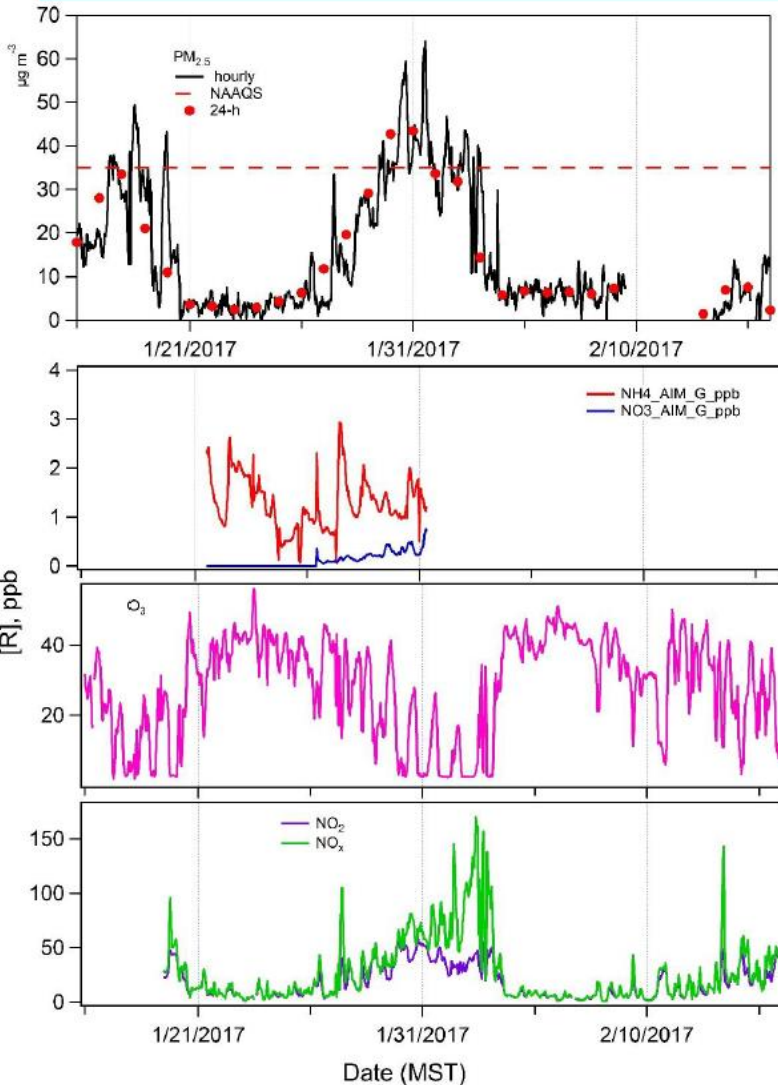


2/2/2017



(Slide from Munkh's presentation.) Ozone anticorrelates with PM but with hysteresis. Vertically, we find anticorrelation outside inversions (with no hysteresis), not during.

## Time Series of PM and Trace Gases at UU



2017 winter



- No obvious trend in NH<sub>3</sub> or HNO<sub>3</sub>.
- In need of AIM data

# General Observations, I

- During inversions: Not seeing a clear relationship between ozone layers and PM layers.
- The strongest inversion at ground (UDAQ O2) is not the strongest inversion at altitude. Especially true for the larger particulates.
- Layers often form in the mornings in a repeatable pattern that moves up and down.
- Afternoon air columns are pretty uniform, regardless of inversion or not.
- Evening breakup of ozone and PM is not uniform with altitude and time. No clear relationships as the air clears out.
- Fast flights are better measurements of the air column since the air is evolving quickly in time. Speed limited by instrument response time.



# General Observations, II

- Outside of the inversion:
  - Relatively uniform air column for PM with higher quantities near ground level.
  - Typical daily sunrise ozone pattern: No altitude dependence before dawn. With sunrise, ozone forms up high before increasing at ground level. Approximately 1-2 hours after sunrise the spatial relation is gone, the column is uniform.
- As the inversion is forming the air column has layers that are somewhat dynamic, but generally repeatable day-to-day.
- During the inversion the air column is reasonably uniform, not surprising given the still air. Ozone altitude sunrise relationship is almost nonexistent.