ANALYSIS OF THE CORRELATION COEFFICIENT BETWEEN CEILOMETER (BACKSCATTER) & TEOM ($PM_{2.5}$) MEASUREMENTS TO ACCESS THE VERTICAL DENSITY OF AEROSOLS

Katherine Lo[1,4]; Jacob Rivera[2,4]; Zaw HAN[3,4]; Yonghua Wu[3,4]; Barry Gross[3,4]

[1] Benjamin N. Cardozo High School, [2] City College Academy of the Arts, [3] Grove School of Engineering, City College of New York, [4] CUNY CREST*

*City University of New York- Cooperative Remote Sensing Science and Technology Center
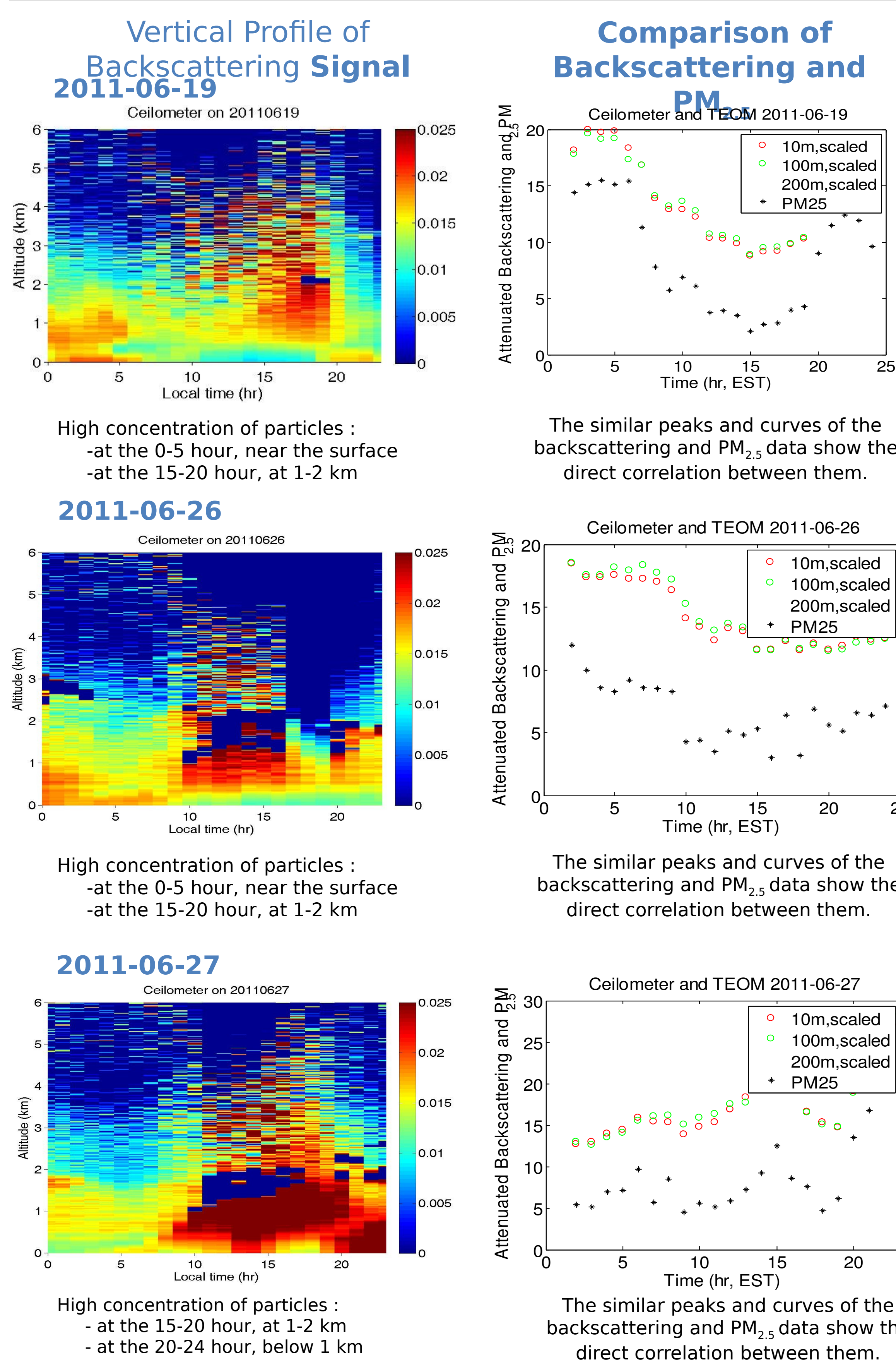
Introduction

-Particulate matter 2.5 ($PM_{2.5}$) :
- Tiny pieces of solid matter suspended in atmosphere as aerosol particles;
- Anthropogenic aerosols have significantly effected human health;
- Causes ≈3% of cardiopulmonary related deaths and ≈5% of respiratory cancer mortalities;
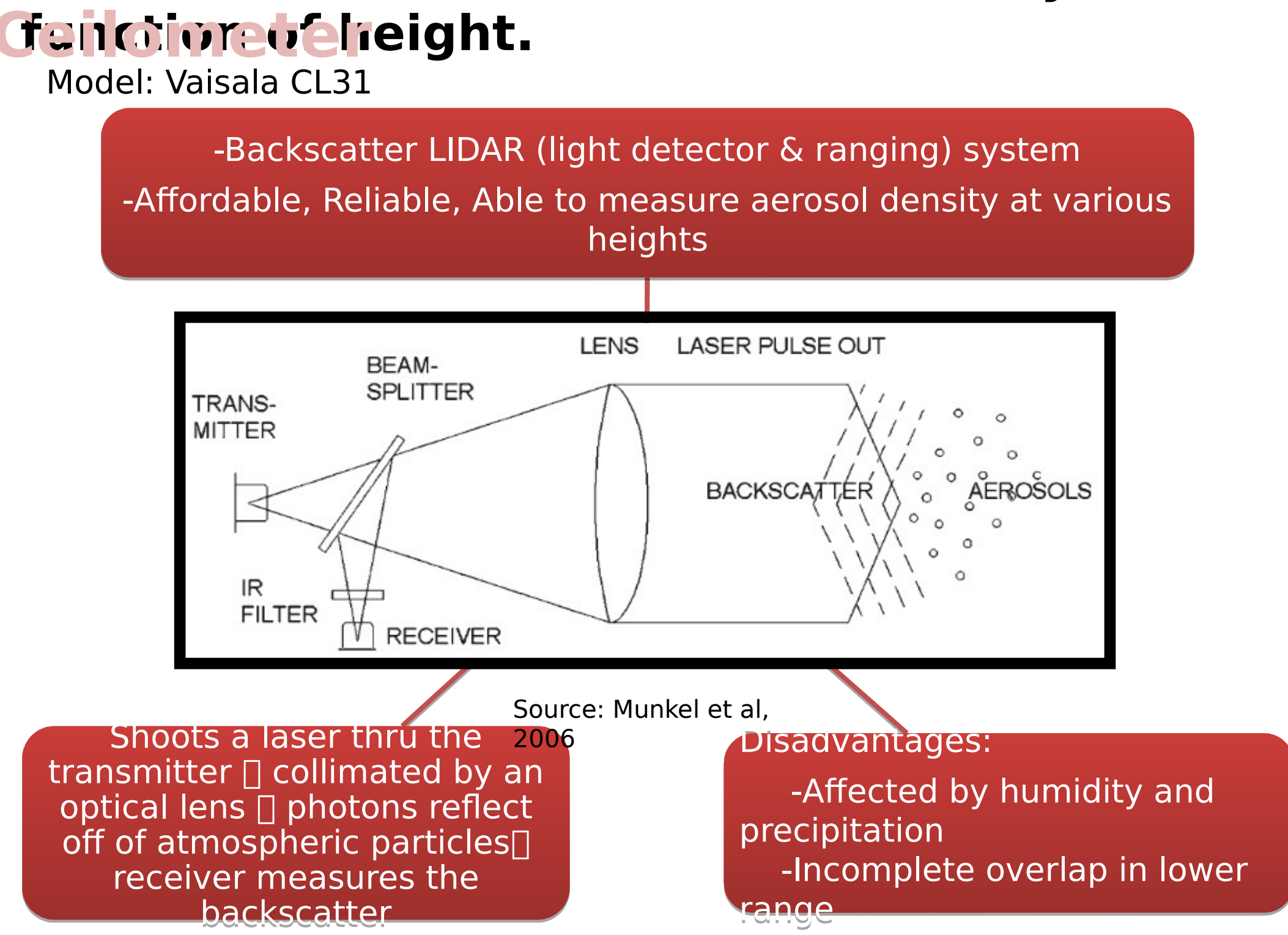- Affects climate by changing the amount of solar absorption and light scattering;

-Air quality forecast models require a good understanding of the vertical distribution of aerosols at various heights within the atmosphere.

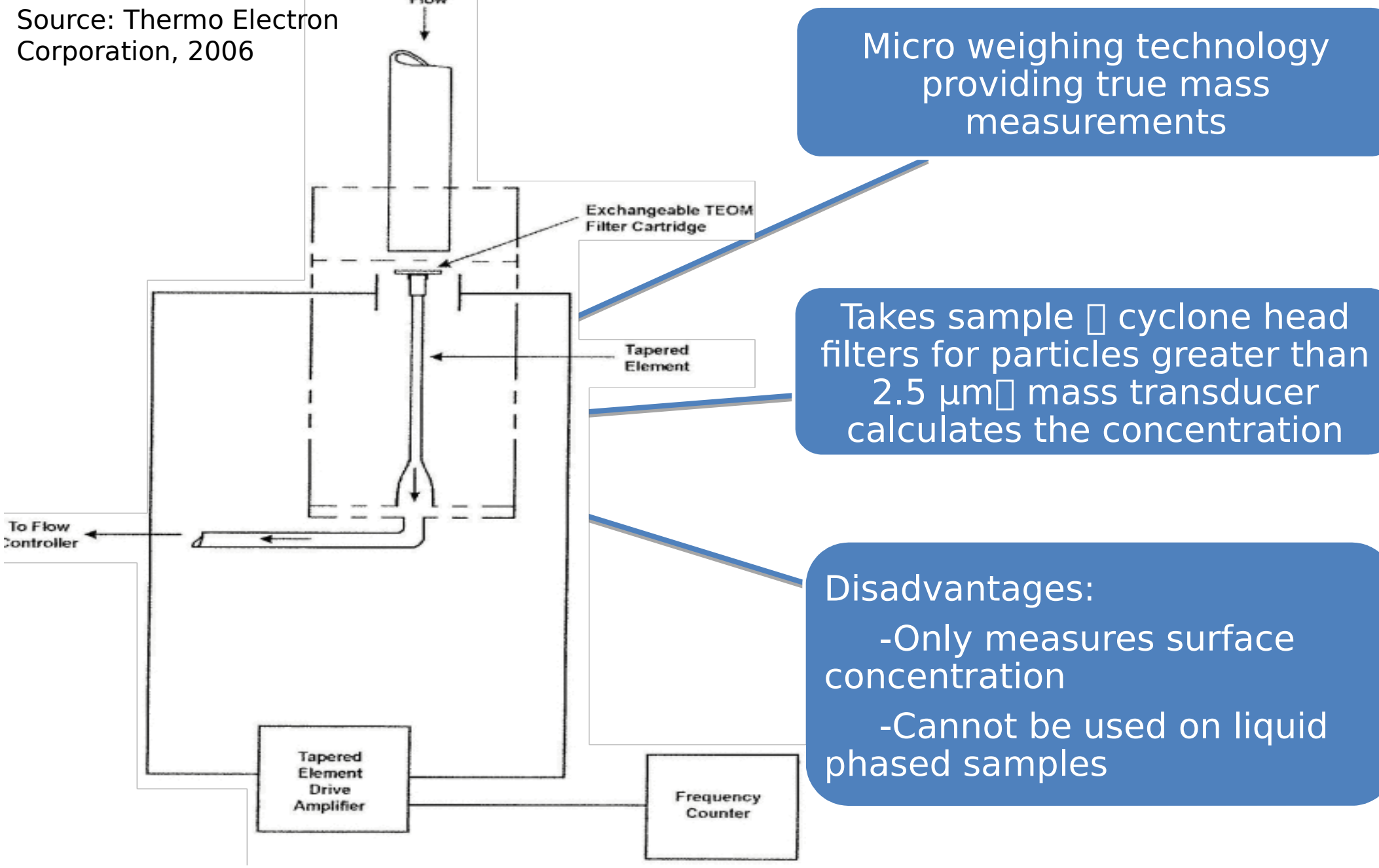**-In this research, we will seek to find the correlation coefficient between the two data sets to test the relationship between** well as to model aerosol density as a function of height.

Materials

Ceilometer
Model: Vaisala CL31

-Backscatter LIDAR (light detector & ranging) system
-Affordable, Reliable, Able to measure aerosol density at various heights

Source: Munkel et al, 2006

Shoots a laser thru the transmitter → collimated by an optical lens → photons reflect off of atmospheric particles→ receiver measures the backscatter

Disadvantages:
-Affected by humidity and precipitation
-Incomplete overlap in lower range

TEOM (Tapered Element Oscillating Microbalance)
Model: Rupprecht and Patashnick 1400a TEOM

Source: Thermo Electron Corporation, 2006

Micro weighing technology providing true mass measurements

Takes sample → cyclone head filters for particles greater than 2.5 μm→ mass transducer calculates the concentration

Disadvantages:
-Only measures surface concentration
-Cannot be used on liquid phased samples

Data & Analysis

*Backscatter: km^{-1} sr^{-1}
$PM_{2.5}$: $\mu g/m^3$

Vertical Profile of Backscattering Signal

2011-06-19

High concentration of particles :
-at the 0-5 hour, near the surface
-at the 15-20 hour, at 1-2 km

2011-06-26

High concentration of particles :
-at the 0-5 hour, near the surface
-at the 15-20 hour, at 1-2 km

2011-06-27

High concentration of particles :
- at the 15-20 hour, at 1-2 km
- at the 20-24 hour, below 1 km

Comparison of Backscattering and $PM_{2.5}$

The similar peaks and curves of the backscattering and $PM_{2.5}$ data show the direct correlation between them.

The similar peaks and curves of the backscattering and $PM_{2.5}$ data show the direct correlation between them.

The similar peaks and curves of the backscattering and $PM_{2.5}$ data show the direct correlation between them.

Correlation between Backscattering and $PM_{2.5}$ Data

R = 0.99
Strong Positive Correlation (r>0.7)

R = 0.83
Strong Positive Correlation

R = 0.89
Strong Positive Correlation

Correlation Coefficient in Relation to Height

The correlation coefficient is strongly positive from the heights 0-300 meters, but decreases significantly at greater heights.

The correlation coefficient is strongly positive from the heights 0-200 meters, but decreases significantly at greater heights.

The correlation coefficient is strongly positive from the heights 0-350 meters, but decreases significantly at greater heights.

Conclusion

- The ceilometer and $PM_{2.5}$ are strongly positively correlated (r > 0.7) at the heights of 10 meters to 300 meters because the atmosphere is most stable and least affected by weatherly factors which affect instrument performance;
- The atmosphere is not particulate homogenous, as shown by the decreasing correlation as height increases;
- As height increases, the concentration of particles decreases in

Future Work

- Further analysis of data using several dates
- Comparison of a series of data sets
- Develop a linear regression formula to represent the relationship between backscattering and $PM_{2.5}$ data

References

1. Munkel, Christoph, Noora Eresmaa, Janne Rasanen, and Ari Karppinen. "Retrieval of Mixing Height and Dust Concentration with Lidar Ceilometer." Spinger, 2006. Web;
2. Thermo Electron Corporation. "TEOM® Series 1400a Ambient Particulate Monitor." 2005. MS. Web.
http://sky.ccny.cuny.edu/wc/Aeronomy/Refs/1400ab_productPDF_27191.pdf
;
3. "PM 2.5 Monitoring. NYS Department of Environmental Conservation, n.d. Web.

Acknowledgements