Projects in the Remote Sensing of Aerosols with focus on Air Quality

Faculty Leads
Barry Gross (Satellite Remote Sensing), Fred Moshary (Lidar)
Direct Supervision
Post-Doc Yonghua Wu (Lidar)
PhD Student Nathaniel Levitan (Satellite Remote Sensing)

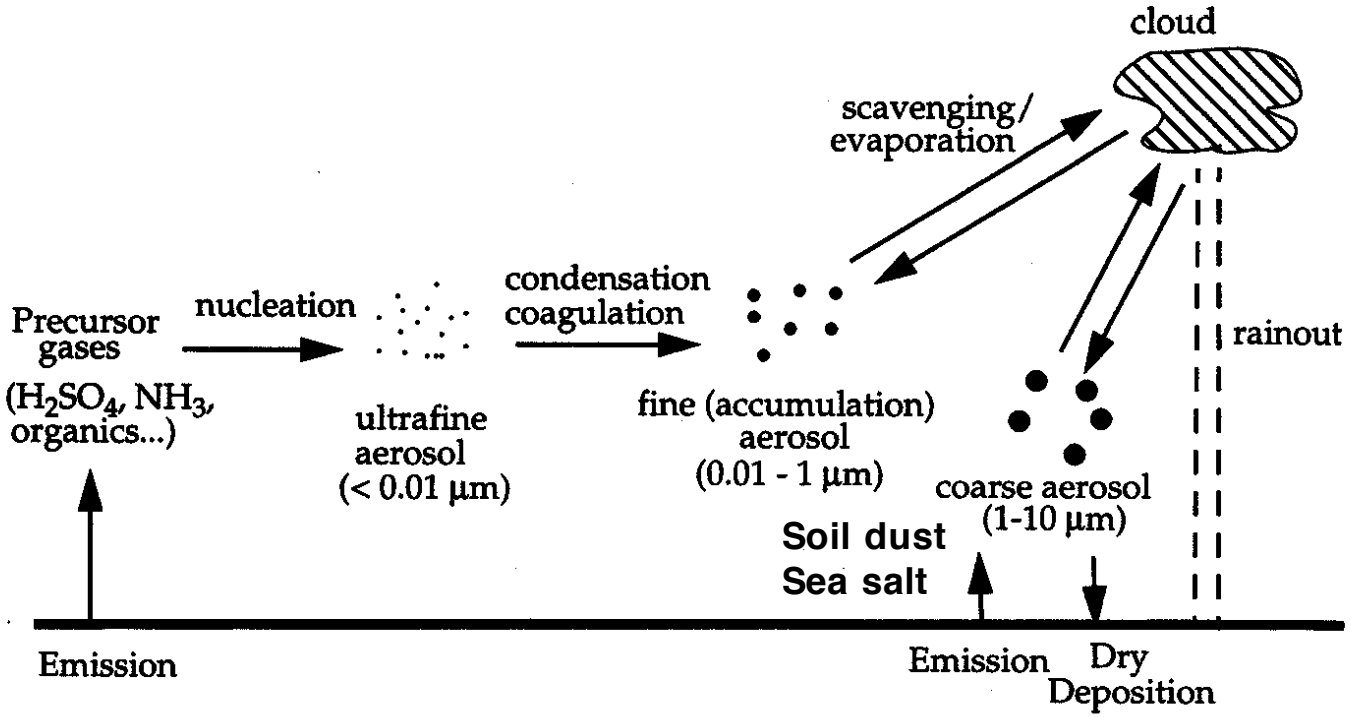
Specific Research areas relevant to HIRES

- How can we use satellite sensors (passive remote sensing) to estimate the total path integrated aerosol loading over land and assess performance. (Unfortunately unable to determine at what height the aerosols are)

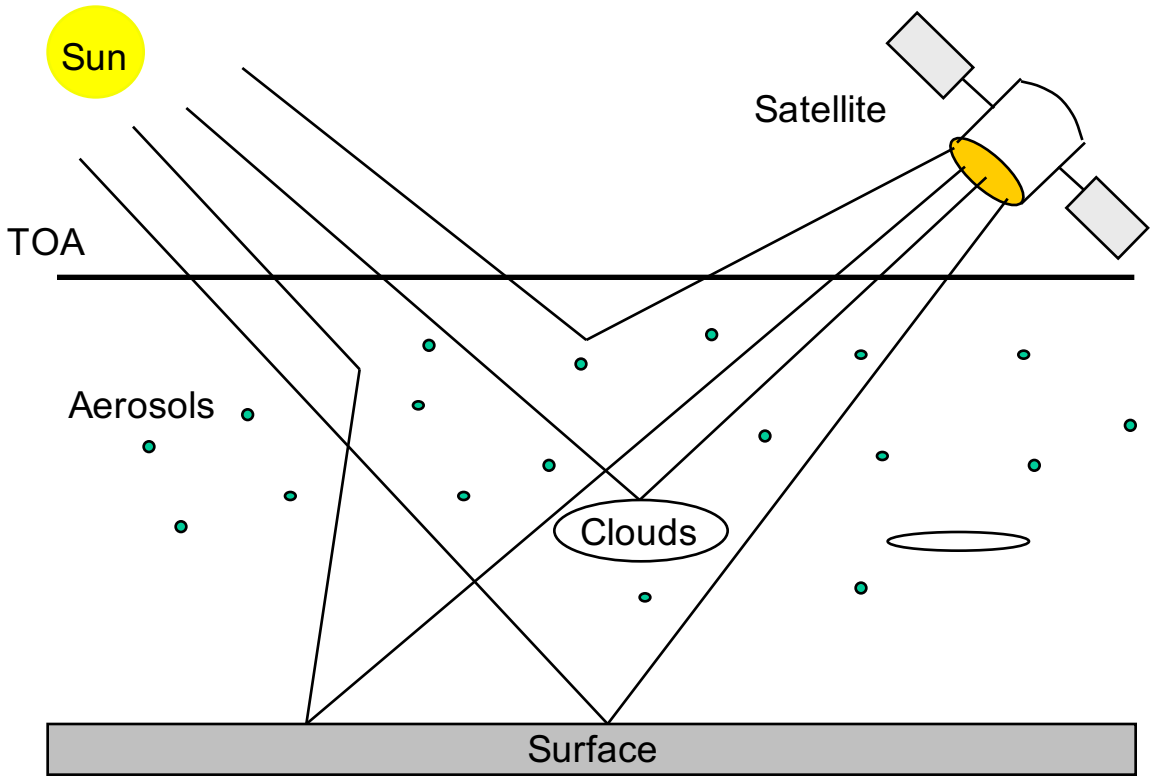
- How can we use active remote sensing (Laser Radars) to probe the vertical distribution of aerosols and use this to better connect satellite remote sensing to near surface particulate pollution.

ORIGIN OF THE ATMOSPHERIC AEROSOL

Size range: 0.001 μm (molecular cluster) to 100 μm (small raindrop)



What does the satellite Sensor See? Reflected Sunlight.



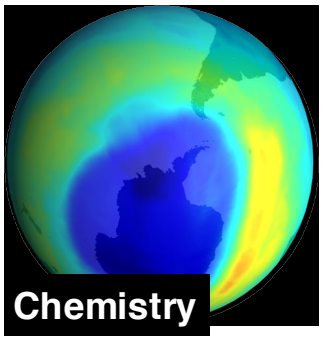
Interactions between the sun radiation and the atmosphere before reaching satellite sensors.

Unfortunately, amount reflected depends on lots of stuff (including the land surface) and not just aerosols

General Problems with Aerosol Retrieval over Land (Urban especially)

- In the presence of surfaces, the top of atmosphere (TOA) reflectance is a combination of the atmosphere reflection and the ground reflection
- Separating the contributions is a very difficult problem depending on the land surface properties especially in urban areas.
- Land Classification from other sources can be used to improve accuracy, remove biases and improve overall spatial resolution

WHY CARE ABOUT ATMOSPHERIC AEROSOLS?



AIR POLLUTION IN THE US :

Ozone and fine particulate matter ($PM_{2.5}$) are the two main pollutants

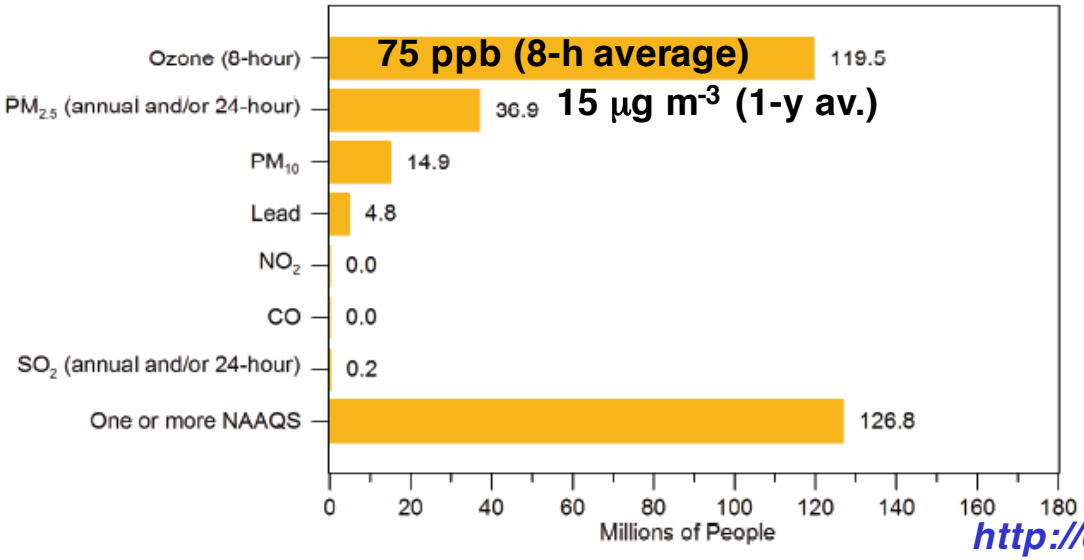
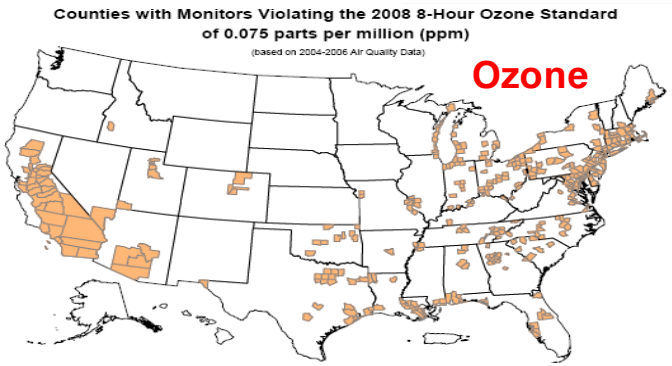
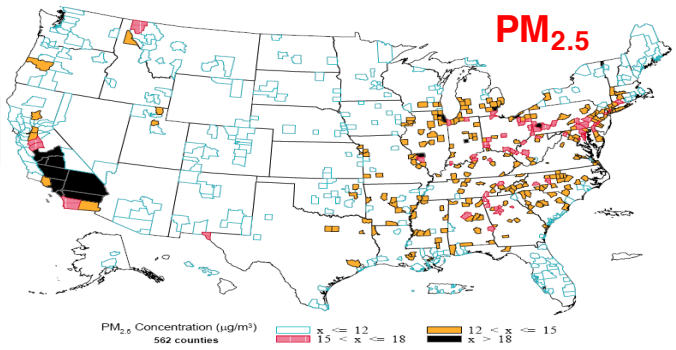


Figure 1. Number of people (in millions) living in counties with air quality concentrations above the level of the primary (health-based) National Ambient Air Quality Standards (NAAQS) in 2008.

Note: Projected population data for 2008 (U.S. Census Bureau, 2008).

http://epa.gov/airtrends/2010/

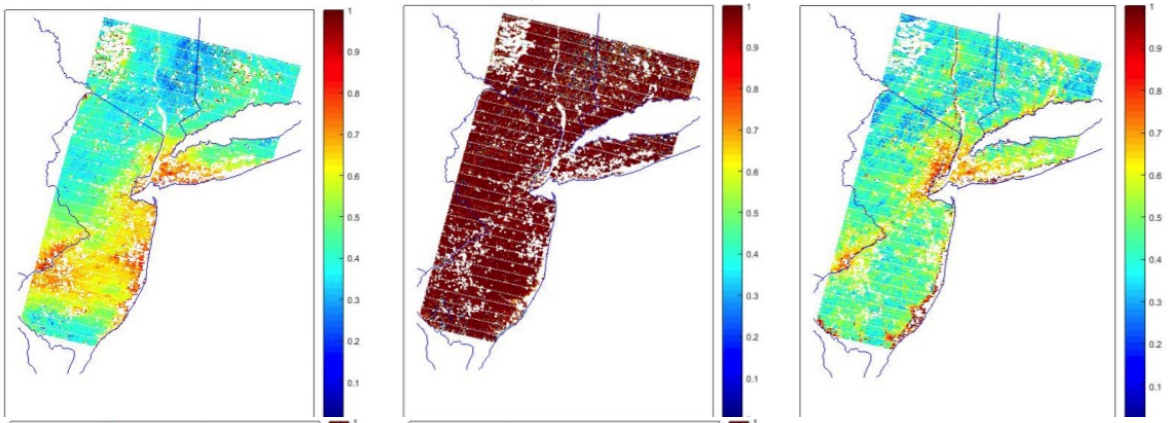




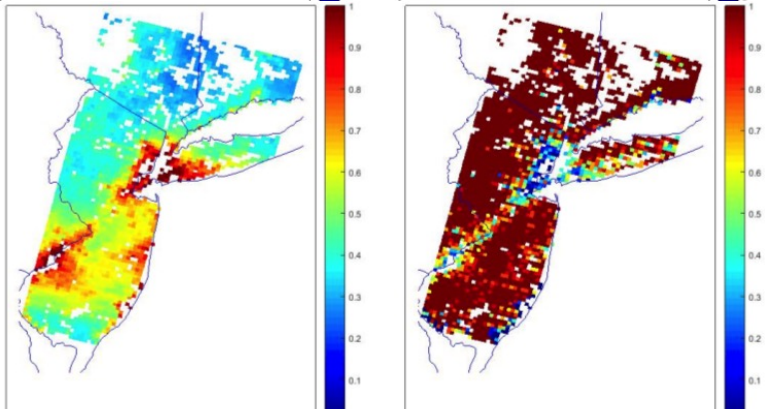
Development of High Resolution Aerosol Optical Depth (AOD =Measure of Column Aerosol Loading)

AOD Retrieval

Fine / Total



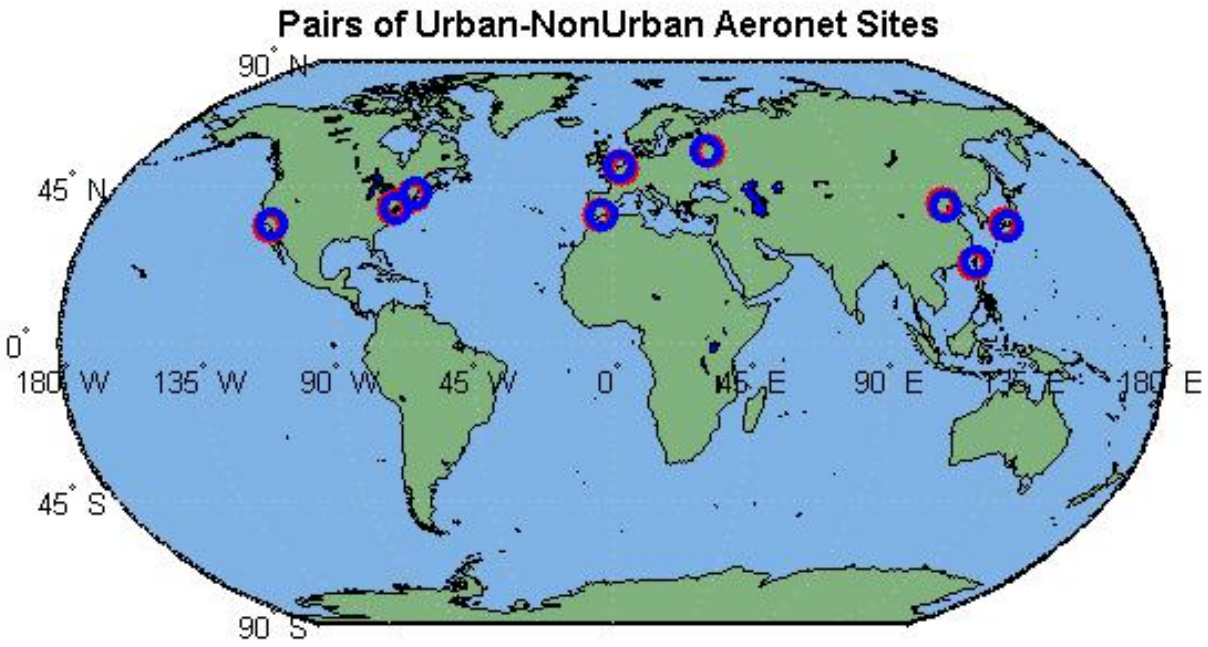
New Algorithm Approach
Single Pixel (500 meters)
Improved Surface Retrieval
More homogeneous Aerosol Fields
No Misidentification of aerosol type



Operational Approach
Aggregate Grid (3km)
Artificial Overestimates of Aerosol Magnitude
Misidentification of aerosol type

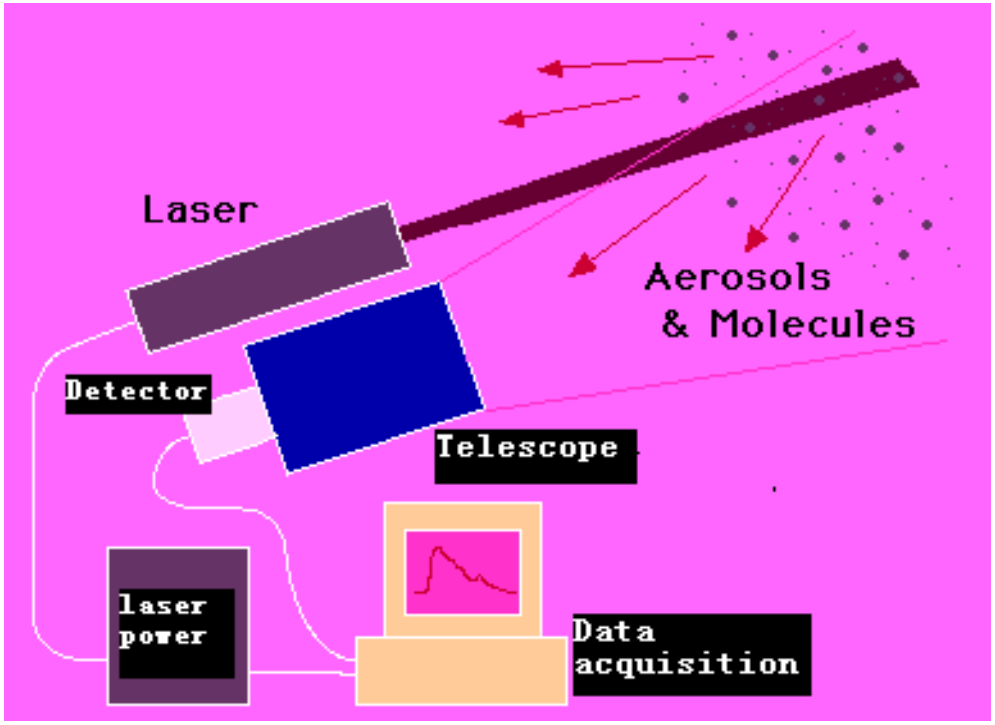
Student Project: Assess Operational 3KM MODIS AOD over neighboring urban-non urban pairs

- Assess and Quantify statistical Bias of AOD matchups with MODIS Satellite against NASA AERONET ground Radiometer network sensors for urban sites
- Bias is often explained due to multiple issues so using neighboring sites where only surface is different (urban / non-urban) is optimal approach

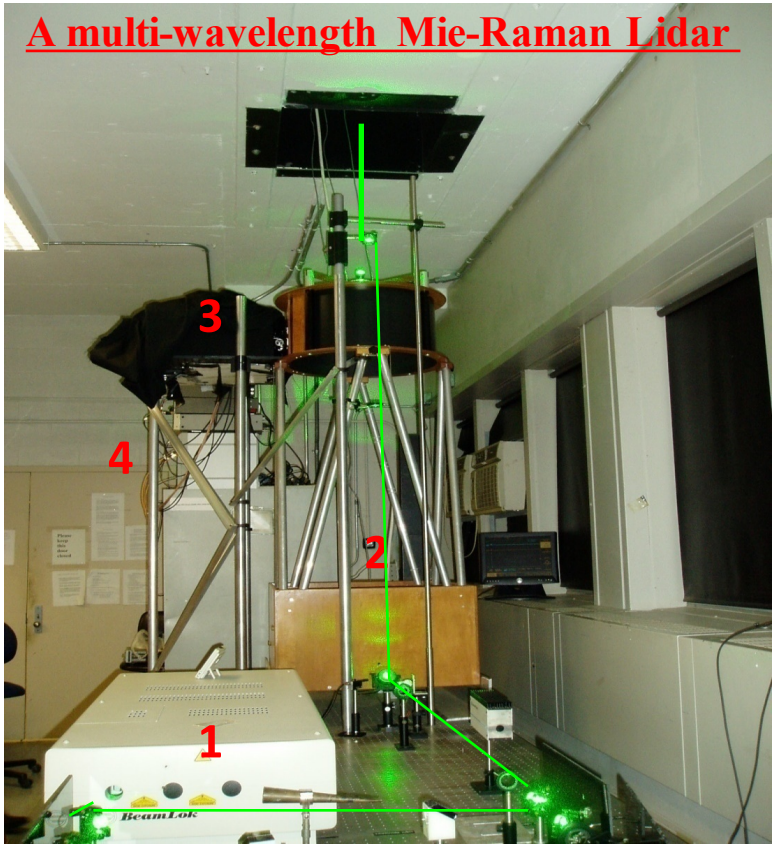


Lidar (Laser Radar) – Determining the range of Aerosols in the Atmosphere

Just as Radar can see large targets such as planes using Radio waves (meter wavelengths), Aerosols can be observed using sources whose wavelengths ~ size of the particles (<1 um)

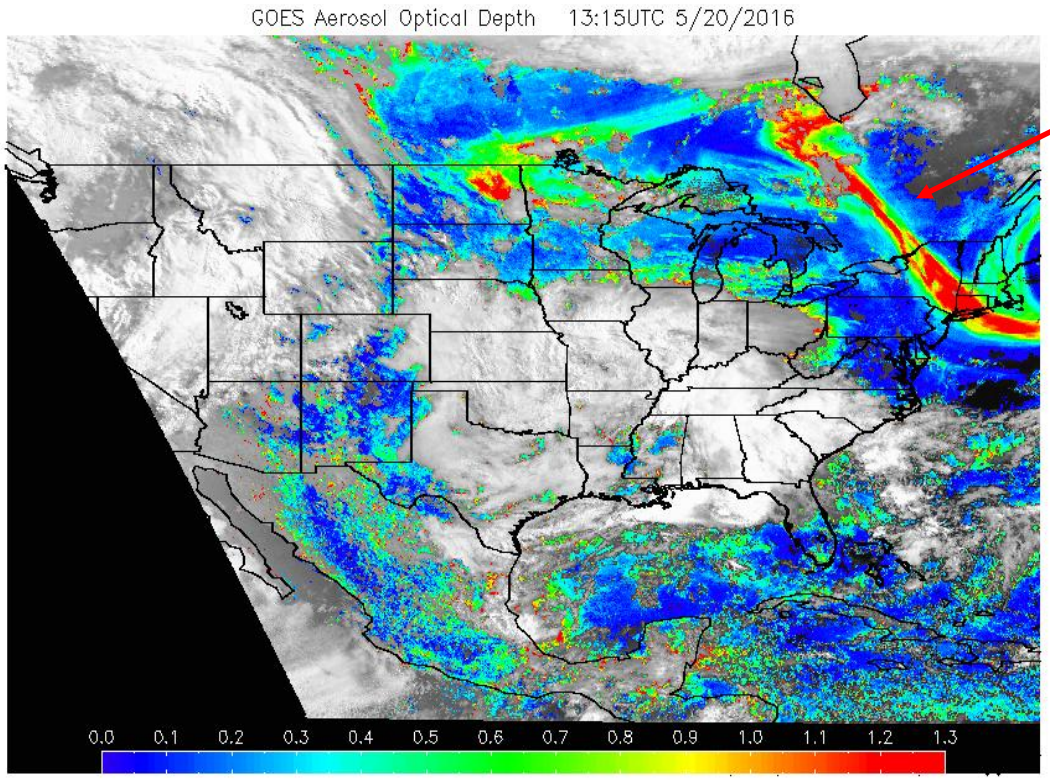


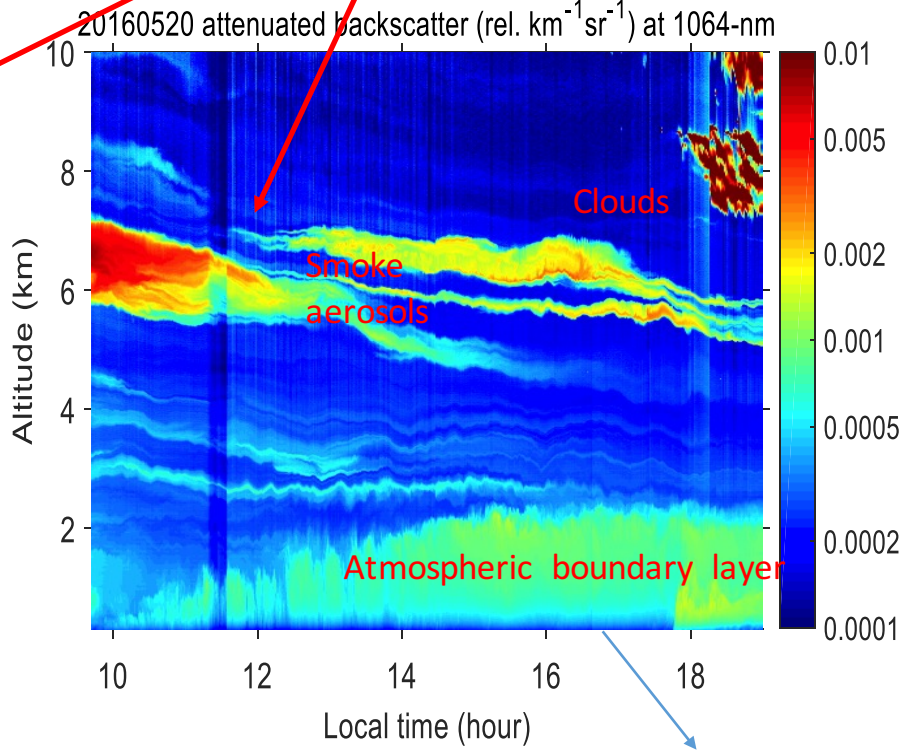
Ground-based atmospheric remote sensing testbed at CCNY



Observe the vertical profiles and column integration of atmospheric aerosol,
Used to evaluate modeling and satellite products and explore pollution events

NOAA satellite GOES Aerosol optical depth. Does high AOD effect Health?



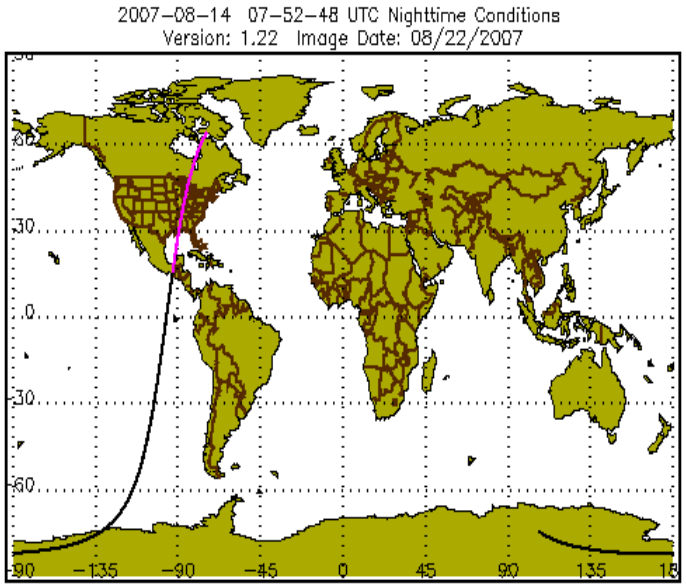


The passive satellite sensor cannot distinguish between aloft smoke and near surface particulates

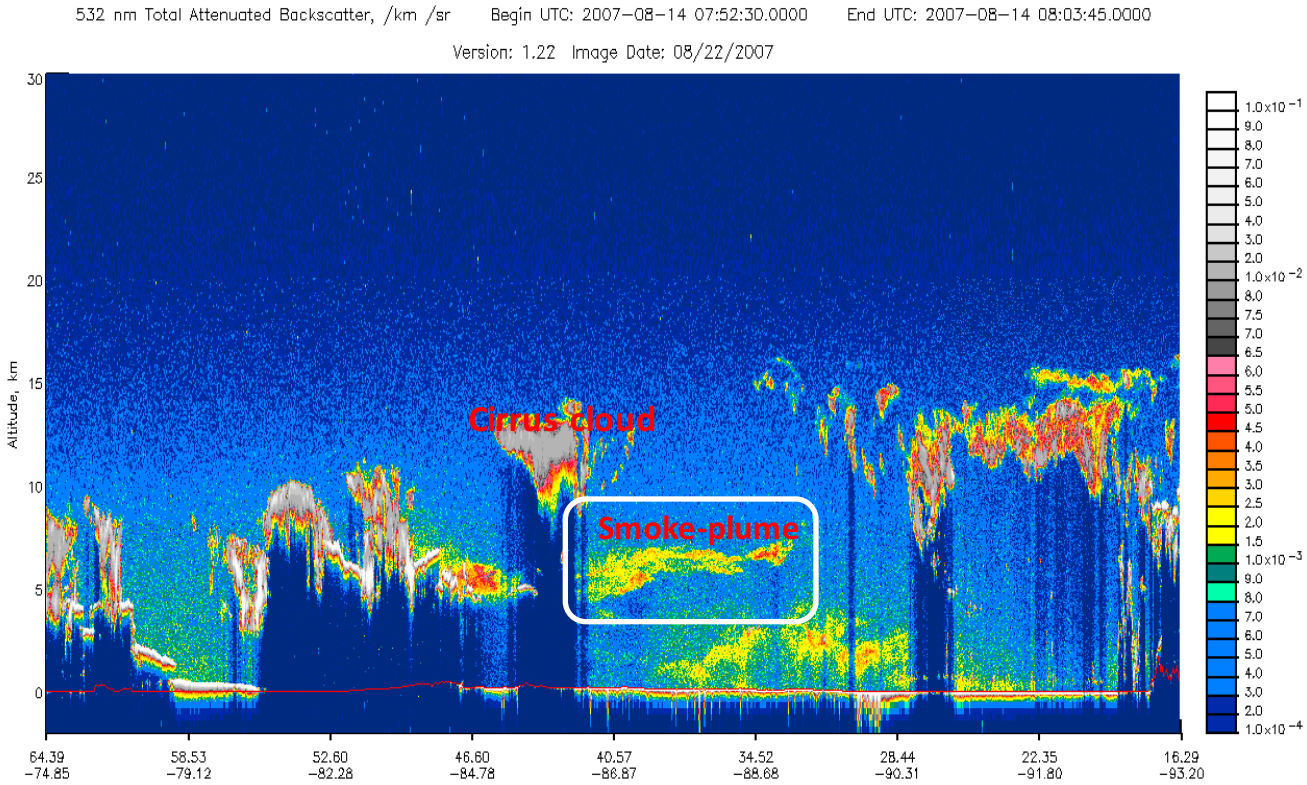
Lidar blind spot
Below 500 meters

CALIPSO- Spaceborne lidar (Mie-scattering+polarization lidar):

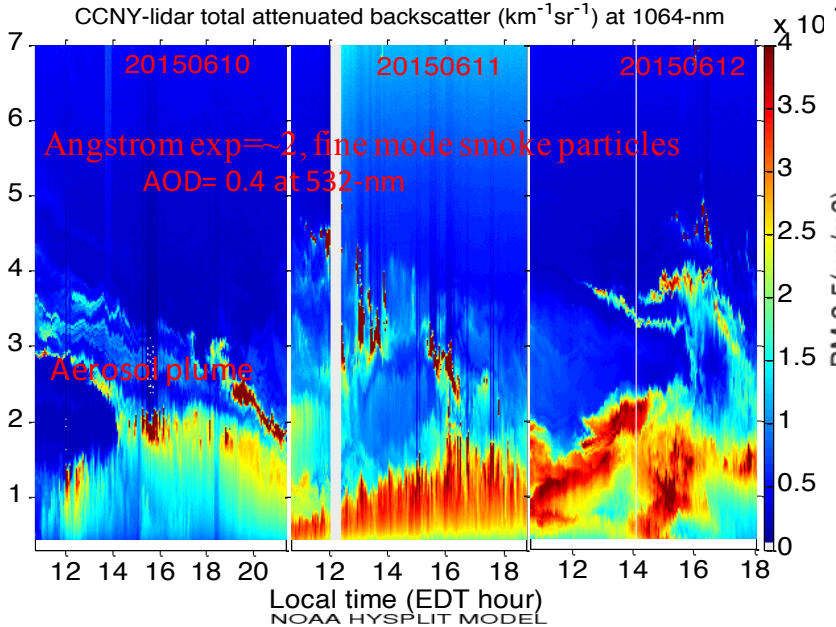
- Global-scale **vertical distribution** of aerosol and clouds
- **Aerosol types**: 2-wavelength channel
- **Cloud-phase**: water or ice clouds

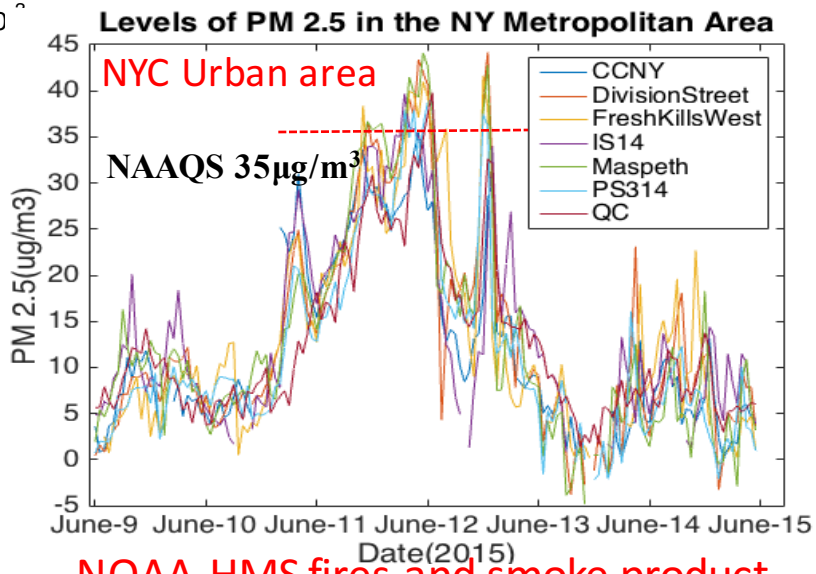


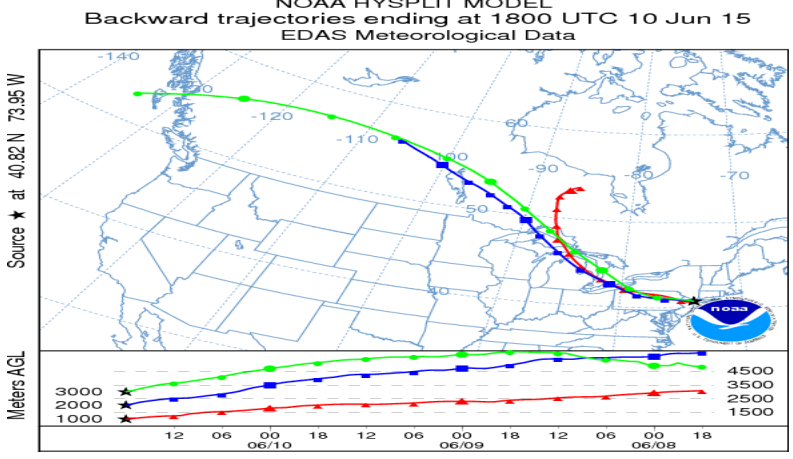
http://www-calipso.larc.nasa.gov/products/



Canadian wildfire smoke transport and impacts on the air quality in NYC

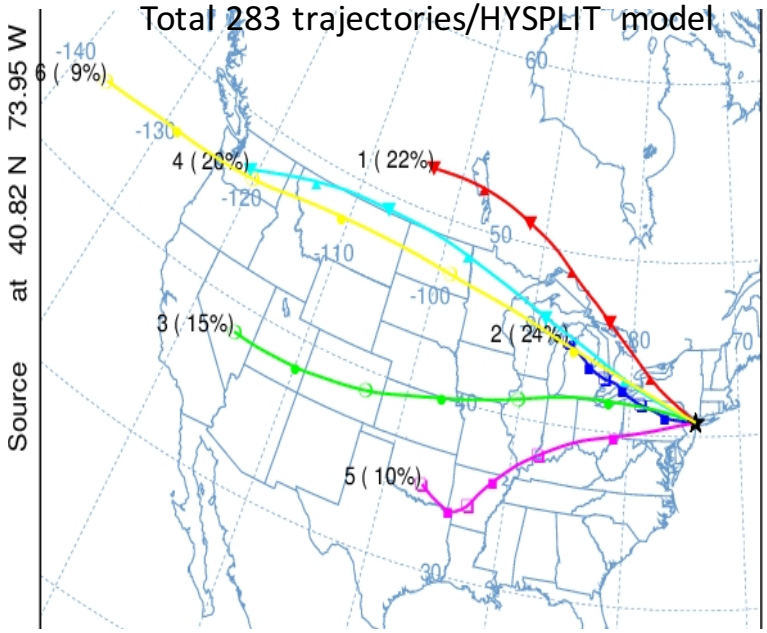






NOAA-HMS fires and smoke product (red spots-fires, gray-smoke)

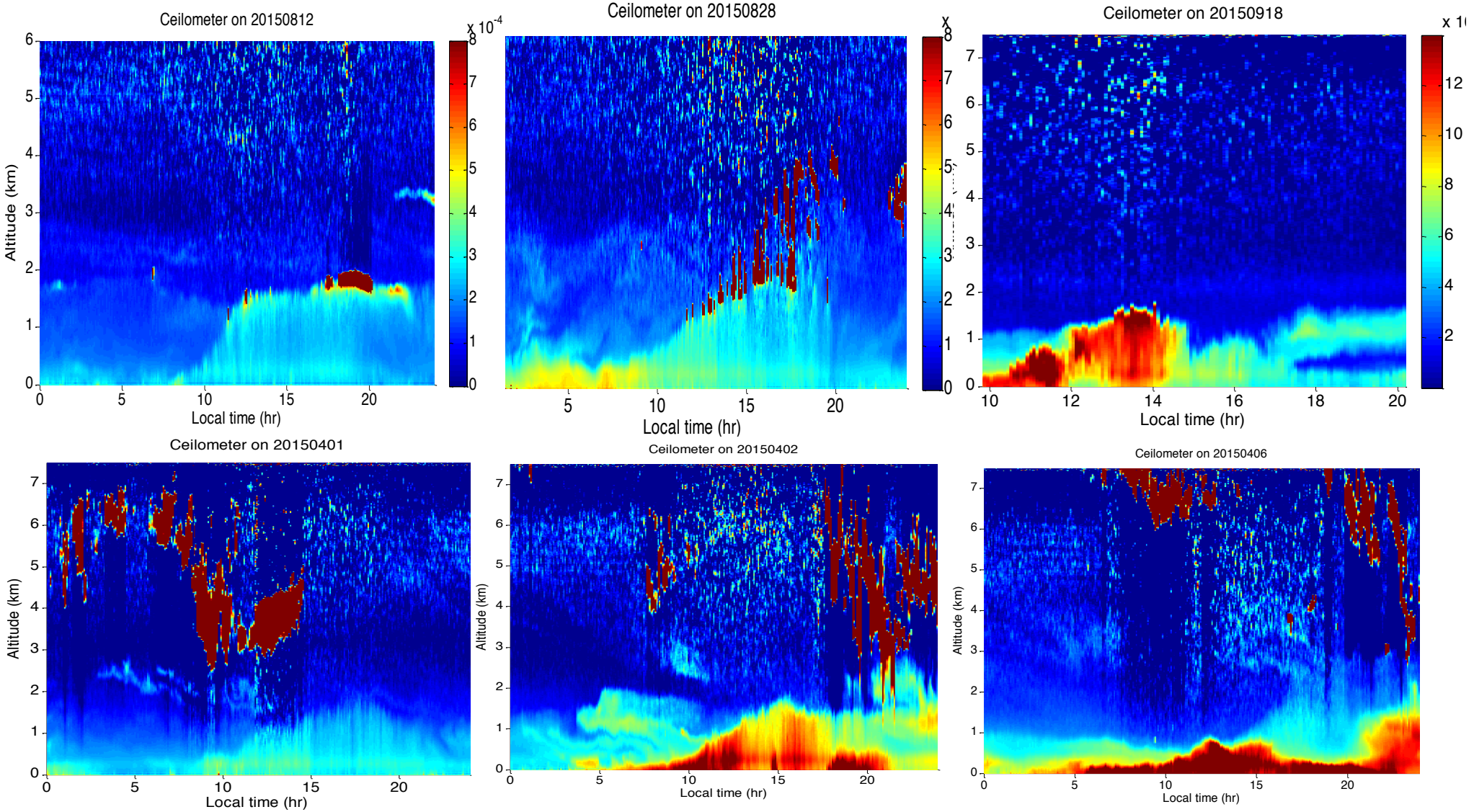
Results: Cluster of transport paths (optical properties)



Cluster #	AOD500	AE	SSA670	Reff (μm)
1	0.19	1.42	0.90	0.28
2	0.31	1.58	0.92	0.24
3	0.22	1.59	0.81	0.21
4	0.25	1.37	0.90	0.23
5	0.16	1.47	0.94	0.20
6	0.15	1.32	0.93	0.31

AE: Angstrom exponent at 440-870
SSA670: single-scattering albedo at 670-nm
Reff: effective radius of aerosol

- Six clusters of transport paths at 4-km level and 72-hr long duration.
- Cluster-2: higher AOD, AE and SSA, small Reff.
  Air-mass transported from the Great Lakes, industrial aerosols.
- Cluster-6: Smaller AE and large Reff, high SSA, trans-pacific Asian dust transport.
- Cluster 1, 3, 4: Smaller SSA and Reff (fine-mode absorbing smoke aerosol)
  Cluster-5: mixture of smoke and dust.


Ceilometer on 20150812
Ceilometer on 20150828
Ceilometer on 20150918
Ceilometer on 20150401
Ceilometer on 20150402
Ceilometer on 20150406
Altitude (km)
Local time (hr)
x 10^-4

Student Project:
Compare and fuse 24/7 Ceilometer with Lidar

- High Power Lidar can see high altitude events but has a blind zone < 500 meters
- Ceilometer can see near the surface (and is cheaper)
- Need to calibrate the ceilometer backscatter with the lidar to allow merging of lidar – ceilometer data
- Air Quality (PM25) near surface can be connected to ceilometer backscatter. Determine correlations and “gain” coefficients for PM25 / backscatter
- Time permitting: Assess Planetary Boundary Layer Height using both instruments using edge detection algorithms