2.6 MESOSCALE WEATHER FEATURES IN NYC REVEALED BY CCNY LIDAR

Stanley David Gedzelman*, Heather Yael Glickman, Barry Gross, Edward E. Hindman, Kwan-yin Kong, Shayesteh Mahani, and Fred Moshary
NOAA Crest Center, City College of New York, New York, NY 10031

1. INTRODUCTION.

Lidar, designed to detect aerosols and cloud particles, doubles as a robust sensor of weather features. Here we use vertical profiles of the tropospheric aerosol and cloud particle content obtained from the City College of New York (CCNY) backscatter lidar in conjunction with soundings and air trajectories based on ARL/NOAA's HYSPLIT model to diagnose local and mesoscale weather features in New York City. The lidar records three wavelengths (355, 532, and 1064 nm), providing 1-minute soundings from 500 m to 15 km with vertical resolution of 10 m. When operating (mostly on clear spring, summer, and fall weekdays), the lidar runs continuously but is automatically shut down when a colocated radar detects aircraft above. Aerosol optical depth (AOD) is calculated from the range corrected power of the lidar signal after Rayleigh scattering of the molecular atmosphere has been subtracted.

2. CASE STUDIES

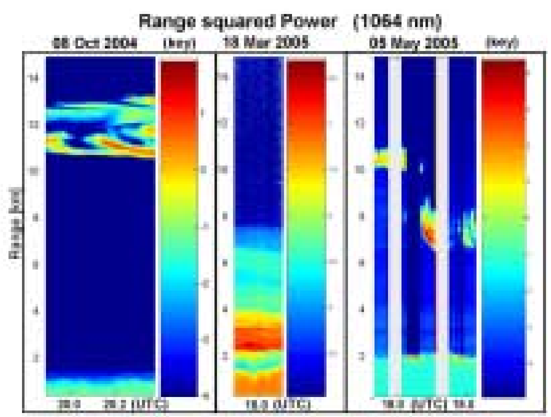

Fig. 1 CCNY vertical lidar profiles for 08 Oct 2004 (left): 18 Mar 2005 (center) and 05 May 2005 (right).

Fig. 1 contains three lidar profiles for three typical situations at CCNY. In the first situation, at least some time on about 65% of the days visibility minima occur at the top of the atmospheric boundary layer (ABL). This indicates a well-mixed ABL with high relative humidity at the top and growth of hygroscopic aerosols by deliquescence. In several cases cloud base occurs near the top of the ABL. In cases where the visibility increases abruptly above the ABL, a subsidence inversion is usually present.

A case in point occurred on 05 May 2005. At 1800 UTC the lidar profile revealed visibility decreasing to the top of the ABL at about 2.0 km where scattered stratocumulus formed. Immediately above the ABL, optical thickness decreased sharply. Higher in the troposphere, two layers of cirrus or cirrostratus were present around 8 and 11 km.

The sounding and trajectory (taken from NOAA Atmospheric Research Labs HYSPLIT model), combined with the lidar profile, give a detailed picture of the weather. The sounding contains a well mixed ABL that is almost saturated at top (Fig. 2). A subsidence inversion with very dry air tops the ABL and caps the stratocumulus. The backward trajectory confirms that the dry air above the ABL descended several km from its source over Canada's NW Territory. But above the subsidence inversion, from 350 to 200 hPa (where the Ci layers occur) humidity is high.

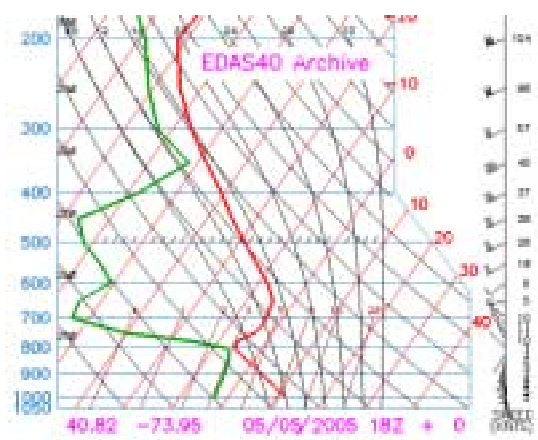

Fig. 2. Sounding for 1800 UTC on 05 May 2005 above CCNY.

On about 40% of the clear days, CCNY lidar profiles contain discrete elevated haze layers that

* *Corresponding Author Address:* Stanley David Gedzelman, Department of Earth and Atmospheric Sciences, City College of New York, New York, New York, 10031 Email: sgedzelman@ccny.cuny.edu

are sandwiched in clear air above the ABL. Determining and locating the source of these layers is a matter of importance for air quality matters. In a few cases, the aerosols are produced by distant forest fires, such as Alaska, Canada, or Siberia (Müller, et. al., 2005). However, most of the elevated haze layers detected by the CCNY lidar are due to anthropogenic activities and, using trajectory analysis, can be traced to surface sources in the United States.

An example of an elevated haze layer with a source around Iowa occurred on 18 March 2005. Around 1800 UTC clean air layer was sandwiched between the top of the ABL at about 1200 m and a well marked haze layer from about 2300 to 4000 m. The sounding for this time shows a well marked top to the ABL, while increasing humidity above 780 hPa coincides with the base of the elevated haze layer (Fig. 3).

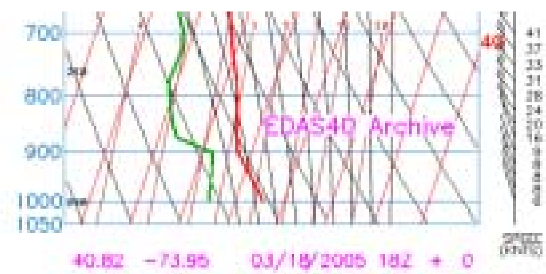

Fig. 3. Sounding for 1800 UTC on 18 March 2005.

Backward trajectories for 1800 UTC 18 March 2005 not only point out the likely origin of the elevated haze layer, but indicate the level of accuracy of model simulations. While air at all levels made its final approach over CCNY from the NW, the air both in the ABL and in the elevated aerosol layer passed through the ABL about 24 h earlier around Iowa while the clean air at 1800 m sunk from 2500 when it was over Wisconsin.

Other common weather situations around New York City are sea breezes and back door cold fronts. When skies remain clear the height and optical thickness of the ABL almost invariably decrease after cleaner air from the sea has moved over CCNY. The typical sea breeze or back door regime is marked by a stable ABL and a lidar profile with visibility gradually increasing upward to high values above the ABL.

This was the case on 08 Oct 2005, a late season sea breeze. The lidar profile reveals visibility that increases to the top of the ABL at about 1 km (left panel Fig 1) topped by clean air. Classical mare's tail cirrus, with head appearing first and tail last, occurs in the lowest kilometer of a layer of cirrus from 11 to 14 km (Wang and Sassen, 2001). The sounding and trajectories are again consistent with this picture. They reveal a poorly mixed, stable ABL with mixing ratio that decreases upward and is capped by stable dry, air through the free troposphere up to the humid air layer with cirrus from 250 to 150 hPa.

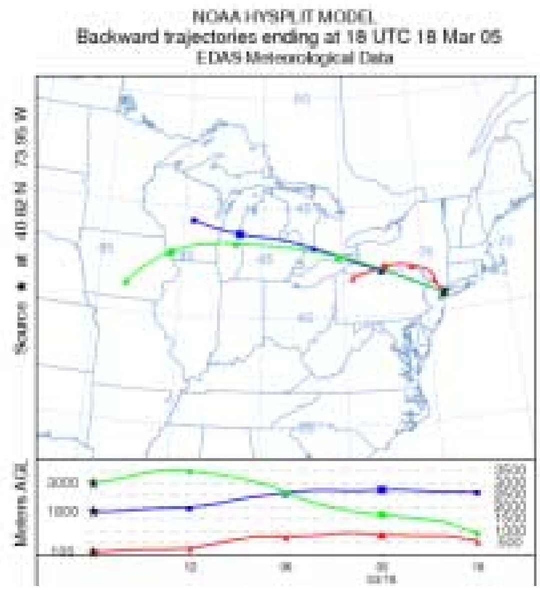

Fig. 4. Backward trajectories for air arriving over CCNY at 1800 UTC 18 March 2005 at 100, 1800 and 3000 m above ground level.

3. SUMMARY

Vertical lidar profiles obtained from the CCNY lidar provide considerable information about local meteorological structure, particularly when used in conjunction with soundings and back trajectories. In a significant number of cases, elevated aerosol layers could be traced back to an origin in the atmospheric boundary layer, strongly suggesting an anthropogenic source.

4. REFERENCES

Müller, D., et. al., 2005: Raman lidar observations of aged Siberian and Canadian forest fire smoke in the free troposphere over Germany in 2003: Microphysical particle characterization *J. Geophys. Res.*, **110**, D17201.

Wang, Z., and K. Sassen, 2001: Cloud type and property retrieval using multiple remote sensors. *J. Appl. Meteor.*, **40**, 1665-1682.