15.3

DEPENDENCE OF REGIONAL MIXING-HEIGHT DIFFERENCES ON BOUNDARY-LAYER WIND SPEED

Robert M. Banta[1], Allen B. White[2], and Wayne M. Angevine[2]

[1]*Environmental Technology Laboratory / NOAA, Boulder, Colorado, USA*
[2]*Cooperative Institute for Research in the Environmental Sciences, Boulder, Colorado*, USA

In a previous study of air pollution over Nashville, Tennessee during the Southern Oxidants Study campaign in July 1995, we found significant differences in mixing height between the subregion to the northwest of the city and that In the other quadrants (Banta et al. 1998). These results were based on airborne lidar and ground-based radar wind-profiler measurements of mixing height during a 3-day stagnation episode. The differences were ascribed to differences in the land-use, vegetation, and geology between the subregions. More recently Angevine et al. (2002) used Nashville 1999 profiler data to show a well developed heat island or 'urban dome' over Nashville during light-wind periods.

These significant differences in mixing height were observed during the light winds of a 3-day stagnation episode. One way of viewing the convective boundary layer (CBL) is as consisting of vertical columns of atmosphere extending through the depth of the CBL and drifting with the mean wind. Then under stagnation conditions, these columns would dwell over relatively localized areas for extended periods of time–probably several hours. Mixed-layer turbulence and depth characteristics should be fully developed, adapted, and representative of the underlying surface. Differences in the underlying surface should be reflected as differences in these characteristics, and the observed mixing-height differences noted by Banta et al. (1998) and Angevine et al. (2002) verify this argument.

However, what happens to these differences as wind speeds increase? We used profiler data for all dry days of the campaign, when we could get good mixing-height measurements from the profiler in each subregion. The results are shown in Fig. 1. The differences essentially vanished when boundary-layer wind speeds reached 6 m s^{-1}. Although a homogenization of CBL properties, including mixing height, is expected for sufficiently high wind speeds (>12 m s^{-1} or so), the evening out of mixing height at wind speeds as low as 6 m s^{-1} was unexpected. Reasons why the mixing height would become more uniform for increasing wind speeds include (1) advection of columns of CBL over different surface types of nonuniform heat flux, and (2) increased contribution to CBL turbulence and mixing properties by mechanical turbulence.

Acknowledgments: This research was sponsored by the Aeronomy Laboratory / NOAA under the Health of the Atmosphere Program.

References:

Angevine, W., et al., 2002: Urban-rural contrasts in mixing height and cloudiness over Nashville in 1999. *J. Geophys. Res.*, accepted.

Banta, R.M., C.J. Senff, A.B. White, M. Trainer, R.T. McNider, R.J. Valente, S.D. Mayor, R.J. Alvarez, R.M. Hardesty, D.D. Parish, and F.C. Fehsenfeld, 1998: Daytime buildup and nighttime transport of urban ozone in the boundary layer during a stagnation episode. *J. Geophys. Res.*, **103**, 22,519-22,544.

Banta, R.M., and A.B. White, 2002: Mixing-height differences between land-use types: Dependence on wind speed. *J. Geophys. Res.*, submitted.

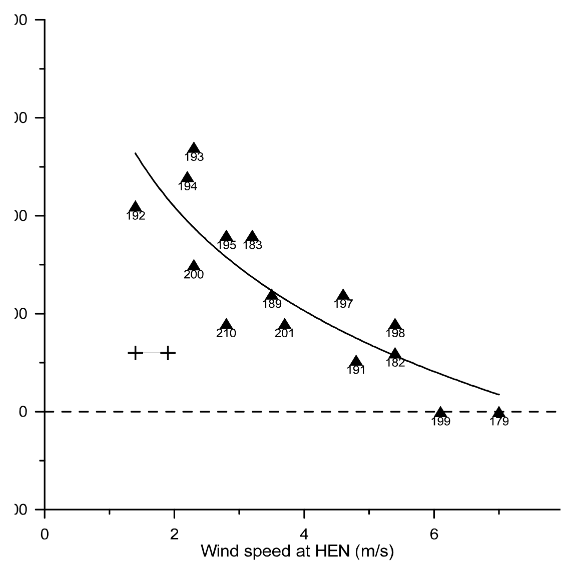

Figure 1: Mixing-depth difference at Hendersonville minus Dickson vs. mean afternoon wind speed at 500 m AGL as measured by profiler. Triangles represent sample of days, with the Julian date indicated, and the two + signs represent two days that followed days of widespread rainfall. Curve is a best-fit logarithmic curve; curve type was chosen arbitrarily.