# Air Pollution and Meteorology at Night – Dependence on Low-Level Jet Properties


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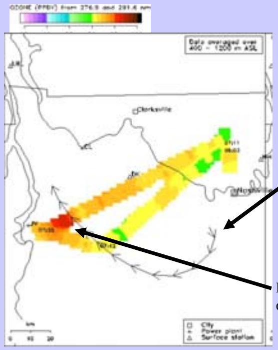
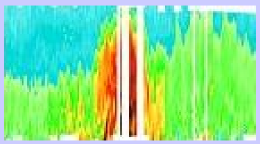
## Previous work




Overnight transport by LLJ - 90 km WSW of Nashville (diagnosed by profiler trajectories, confirmed by airborne $O_3$ lidar measurements)



Pollution dome stayed over Nashville on previous afternoon.

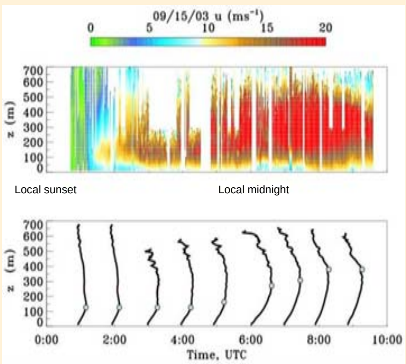
*SOS Nashville'95: Banta et al. 1998*

## INTRODUCTION

A key aspect for better understanding of nighttime chemical processes is nocturnal boundary layer meteorology, which determines the concentrations of the pollutant species present, the mixing of pollutants from different sources, and how much polluted air from the boundary layer is subjected to dry deposition by being brought into contact with the surface.

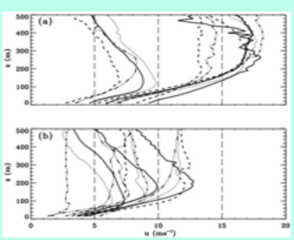
Two key quantities that control pollutant concentrations and mixing in the SBL are the mixing depth and the intensity of the turbulence. Analysis of data from two nocturnal BL field campaigns over the U.S. Great Plains has indicated that the mixing depth is closely associated with the height of the Low Level Jet (LLJ) maximum, that forms after sunset, and the turbulence intensity is proportional to the LLJ speed. In this study we investigate these properties of LLJs as measured at sites in Kansas and southeastern Colorado.

## Evolution of LLJ trough the night



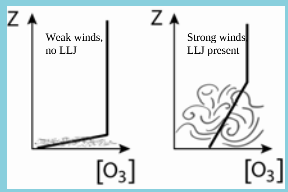

Time-height cross sections of streamwise velocity calculated from HRDL vertical-slice scans.; data averaged over (top) 1-min time interval, (bottom) over 1-hour. The magnitude range of each wind profile in the bottom panel is 5-20 m $s^{-1}$.

## Linear shear below L LJ

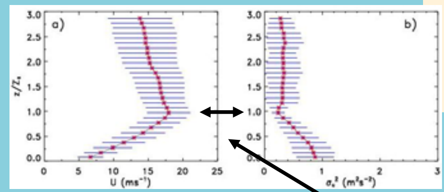


Profiles of mean streamwise velocity composite for each night of HRDL observations during (a) Lamar-03, and (b) CASES-99 experiments. Different lines in both plots represent different nights; exact dates not important in this context.

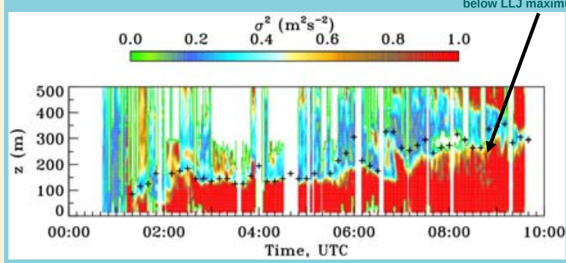
## Relations between LLJ maxima and height of the mixing layer



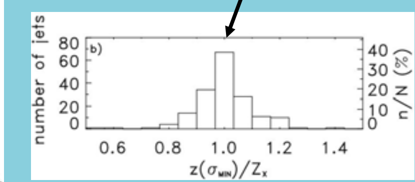

Nights with strong LLJs exhibit mixing through a deeper layer. With weak winds the SBL may be only 10 m deep.



Composite profiles of (a) streamwise velocity and (b) variance for several strong wind nights from CASES-99 and Lamar experiment

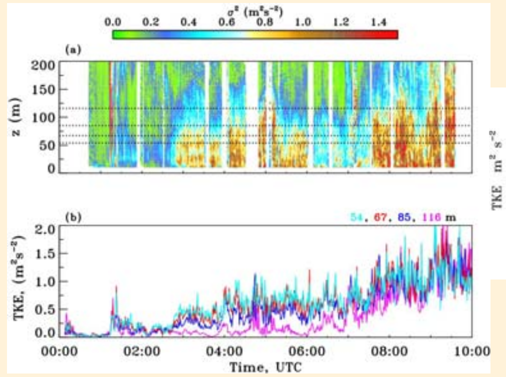



Time-height cross sections of the streamwise velocity variance calculated from HRDL vertical-slice scans during night of September 15. Vertical profiles of the streamwise velocity variances were shown to be numerically equivalent to turbulence kinetic energy (TKE) for stable conditions. The height of the LLJ wind maximum is indicated by plus signs.

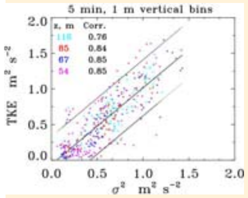



Histogram of height of minimum streamwise velocity variance normalized by height of LLJ maxima. Both plots indicate a close relations between top of shear generated turbulence and LLJ nose.

## HRDL-measured streamwise velocity variance – numerical equivalent to TKE



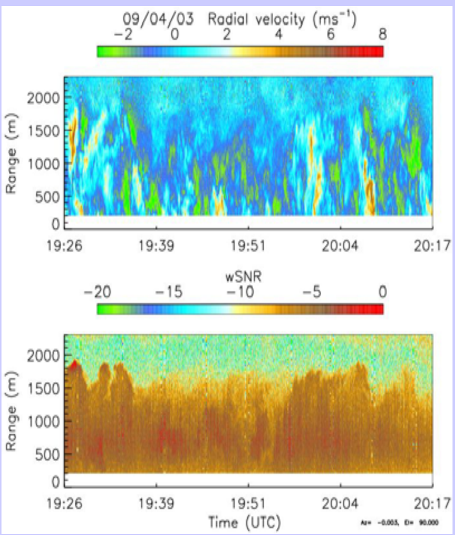

Time-height cross sections of HRDL streamwise velocity variance (a) show good agreement in pattern with time series of TKE measured by sonic anemometers at 4 heights indicated in (b) by different colors.




Scatter plots of sonic- anemometer measured TKE at four heights, and the streamwise velocity variance, calculated from HRDL vertical slice scans at the same heights.

## Near future work

BL height estimate from fixed-beam HRDL scans by determining the range gate for which the backscatter signal exceeds the signal value from the clear atmosphere




Time-height cross sections of the (top) vertical velocity and (bottom) signal-to-noise (SNR) ratio obtained from HRDL scans pointed vertically during a late afternoon.

## CONCLUSIONS

- **The high temporal and spatial resolution of the HRDL data allow investigation of wind-speed and turbulence conditions in great detail within the nocturnal boundary layer**
- **Quantities of interest for nighttime boundary layer meteorology that can be easily monitored using Doppler lidar include LLJ properties (speed, height, direction) and characteristics of the turbulence below the jet, including estimates of TKE profiles.**
- **The peak magnitude of the TKE below the LLJ during strong wind nights is proportional to the speed of the LLJ.**
- **The LLJ maximum and the height of the minimum value of the streamwise velocity variance profile are strongly related with a proportionality coefficient close to one, so the LLJ height could be a measure of the height of the nighttime boundary layer.**