Objective Determination of CBL Depth by Application of a Haar Wavelet Algorithm to Aerosol Lidar Images

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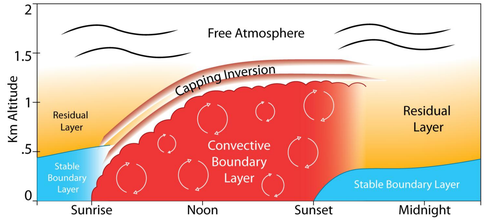
Motivation: Routine measurements of the depth of the daytime convective boundary layer (CBL) over land are needed to control air quality and initialize and evaluate numerical weather simulations.

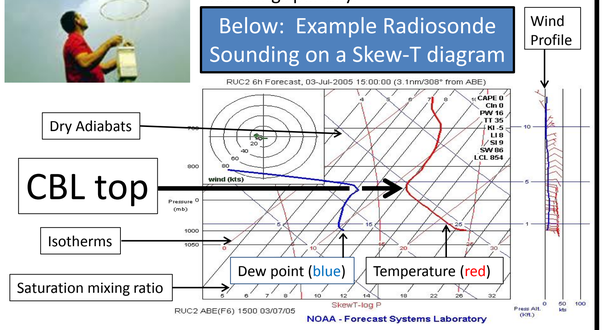


Research Objectives:

1) Collect data in Chico during the summer of 2012.
2) Apply a wavelet-algorithm described by Davis et al. (2000) to vertical scans from the REAL to determine CBL top.
3) Compare CBL height measurements derived from the lidar with those derived from the nearby NOAA radar profiler.
4) Use observations of CBL depth to assist in air quality forecasting and weather model validation.

The depth of the CBL can be determined by *in situ* measurements. Radiosondes are carried aloft by balloons (or aircraft) to measure vertical profiles of temperature, humidity, and pressure. The CBL depth is determined from a distinct change in the vertical gradient of temperature. While this is a robust method, it is typically limited to a few soundings per day.

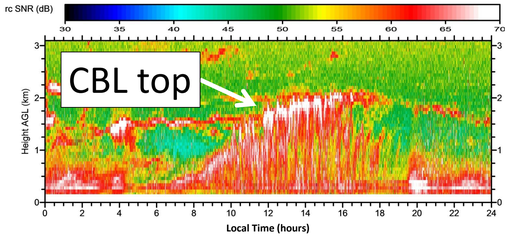
Below: Example Radiosonde Sounding on a Skew-T diagram

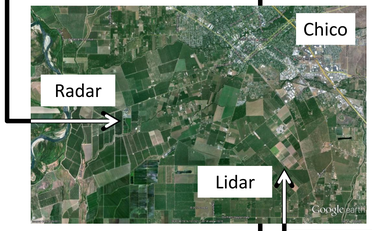


Comparison of remote sensing methods for observing the CBL

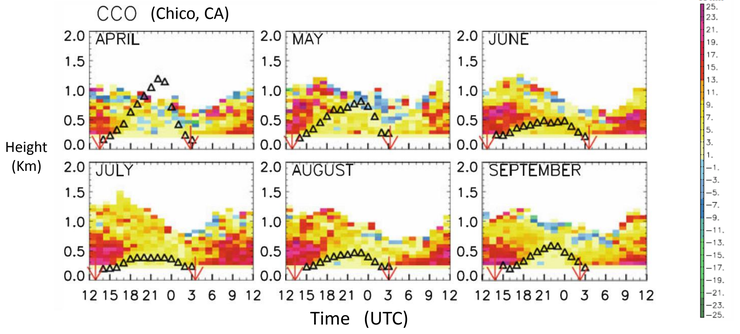
Doppler Radar Wind Profiler

Wind profilers are small Doppler radars that use stationary, phased-array, antennas to project microwave radiation vertically. Radar "echoes" or "backscatter" is generated in the clear atmosphere from inhomogeneity in the radio-refractive index. The radars are particularly sensitive to Bragg scattering. The height of the boundary layer can be determined by the identification of a maximum in backscatter that typically corresponds to the entrainment zone.





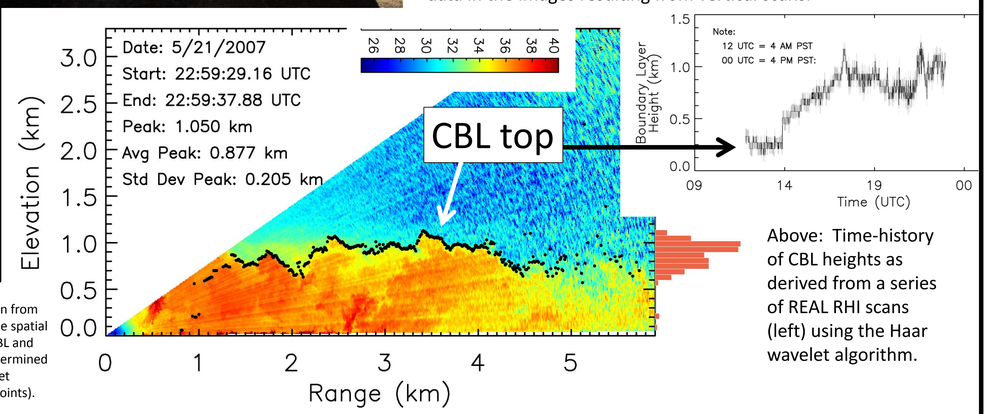
Dr. Laura Bianco (NOAA) developed algorithms and applies them to objectively identify the CBL height from profiler data (above). These data have been used to begin developing climatologies of CBL height in the Central Valley. Below, triangles show mean CBL height in Chico for the months of April – September 2008. Diurnal monthly-averaged lapse rate of virtual potential temperature is shown in color (Bianco et al. 2011).



Scanning Aerosol Lidar

The REAL (Mayor et al. 2007) has been located at CSU Chico since August of 2008. The CBL often shows up very well in the vertical scans (RHI). This is because activity at the surface of the earth is the primary source of particulate matter. The overlying "free atmosphere" is typically cleaner. Therefore the top of the CBL appears as a dramatic decrease in aerosol backscatter as one ascends.

The top edge of the CBL can be objectively identified in the lidar data by applying Haar wavelets to the columns of backscatter data in the images resulting from vertical scans.



Above: Time-history of CBL heights as derived from a series of REAL RHI scans (left) using the Haar wavelet algorithm.

Right: One RHI scan from the REAL shows the spatial structure of the CBL and its top edge as determined by the Haar wavelet transform (black points).

Timeline for Research: We plan to operate the REAL during the summer and autumn of 2012. Data processing and comparison of radar and lidar CBL heights will then take place and a thesis and journal article are to be completed by summer 2013.

Acknowledgments

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References

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