Evaluation of the Atmospheric Boundary Layer behavior

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The Atmospheric Boundary Layer (ABL) is the part of the troposphere that is directly influenced by the Earth's surface and responds to surface forcing by frictional drag, evaporation and sensible heat transfer with a timescale of an hour or less (Stull,1988). In this way, the ABL usually has a much higher concentration of aerosols than the free troposphere above. As a result, in relation to lidar operation, backscatter signal appears at this atmospheric layer.

Instrumentation and methodology

LIDAR

The region bounded by the top of the ABL and the free troposphere is called the Transition Zone (TZ). A convenient way to determine the local ABL depth is to estimate the height of ABL top. From a lidar perspective the TZ is defined by an abrupt change of the backscatter signal. In our case, an algorithm was implemented using the Haar Wavelet Transform in order to estimate the ABL top and therefore its depth by identifying the major gradient over a lidar backscatter profile (Brooks, 2003). For this purpose we use the parameters of our coaxial lidar. Our system, located at La Paz, Bolivia (16.5ºS,68.1ºW,3420 *masl*), works with a Nd/YAG laser (532nm) in a coaxial configuration.

$$h\left(\frac{R-b}{a}\right)=\begin{cases}+1 & b-\frac{a}{2}\le R\ge b\\ -1 & b\le R\ge b+\frac{a}{2}\\ 0, & \text{elsewhere}\end{cases}$$

Haar Function

$$W_f(a,b)=\frac{1}{a}\int_{R_b}^{R_t} f(R)\,h\left(\frac{R-b}{a}\right)dR$$

Haar Wavelet Transform

h: *Haar function.*
R: *Altitude.*
b: *Location at which the Haar function is centered (translation of the function).*
a: *Spatial extent (dilation).*
Wf: *Haar Wavelet Transform.*
f(R): *Signal of interest, in this case a range corrected profile.*
Rt and Rb: *Upper and lower limits of the signal f(R).*

A maximum in $W_f(b)$ identifies a step in $f(R)$ with a coherent scale of ¨a¨, located at $R= b$.

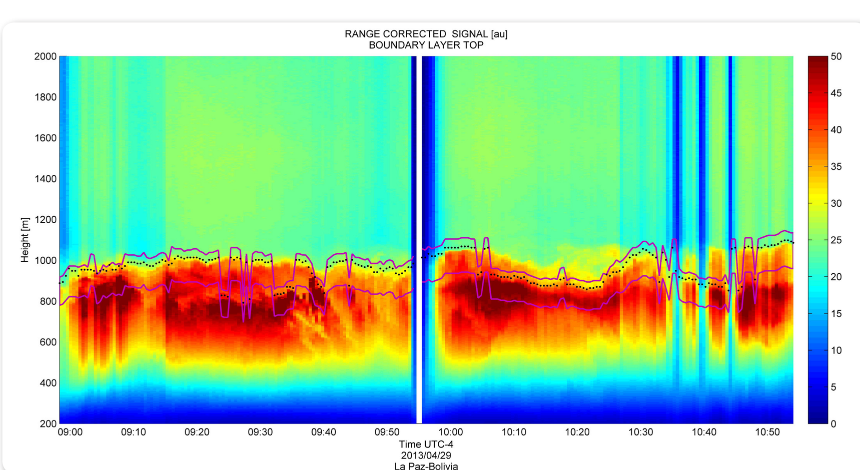
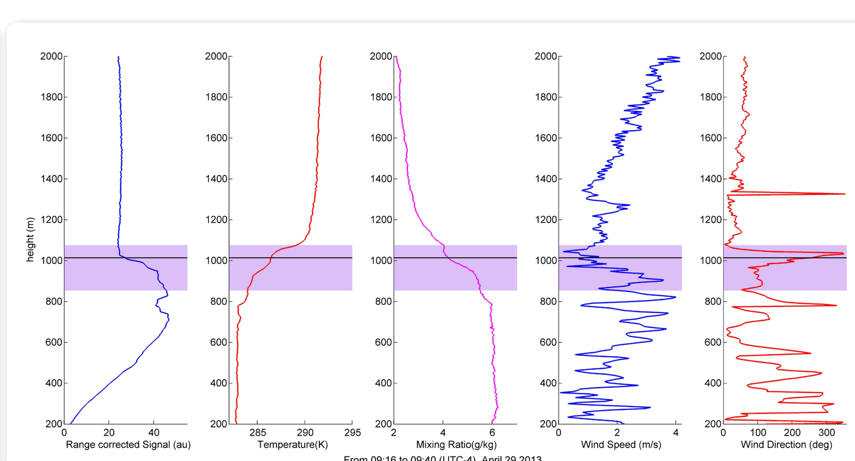
RADIOSONDE

In order to have a better understanding about the behavior of the ABL and to complete the information obtained from a lidar backscatter profile, meteorological parameters from radiosoundings were used to study the atmosphere inside and above the ABL. For this purpose co-located radiosondes were launched every other week for several months of 2013 when the lidar systems was in operation. The systems used for this purpose were iMet -1ABX with sensors of temperature, relative humidity, pressure and GPS. Profiles for Potential Temperature (θ), Water Vapor Mixing Ratio (X), Wind Speed and Wind Direction were obtained from these data.

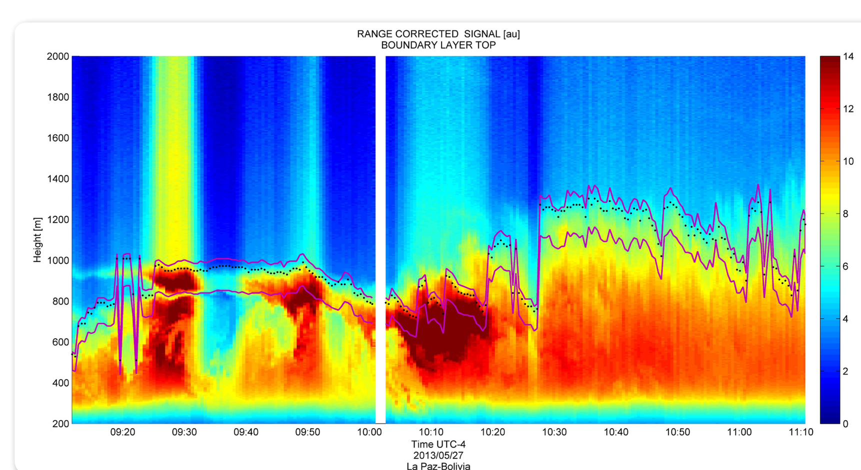
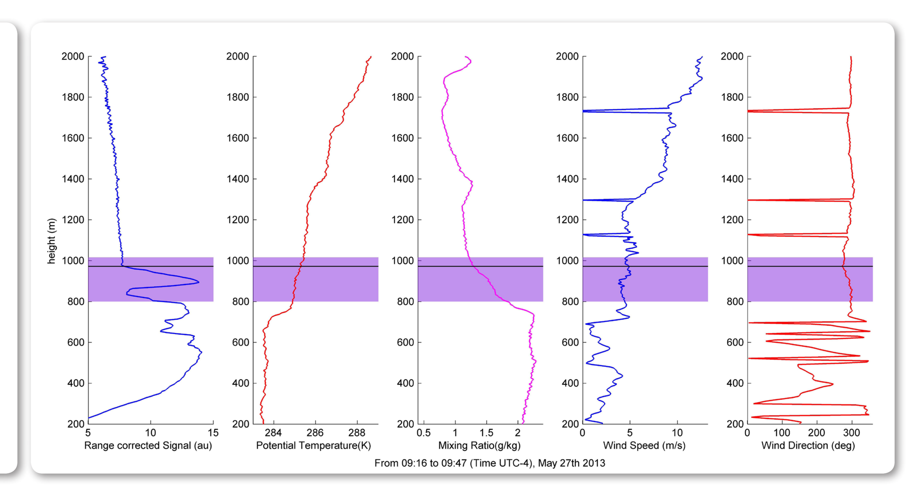
$$\theta = T\left(\frac{P_0}{P}\right)^{R/C_P}$$

θ: *Potential Temperature.*
T: *Temperature.*
P_0: *Pressure at ground level.*
P: *Pressure.*
R: *Gas constant.*
C_p: *Specific heat capacity at a constant pressure.*

Local Atmospheric Boundary Layer Behavior (La Paz-Bolivia, 2013)

(April 29th)

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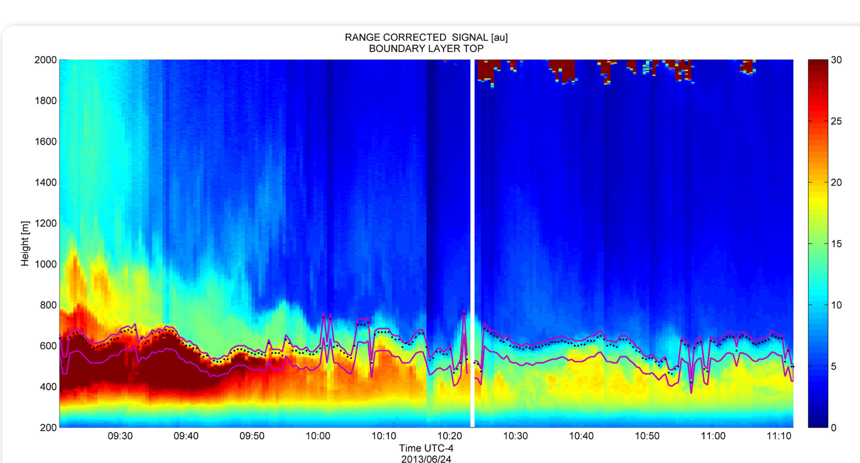
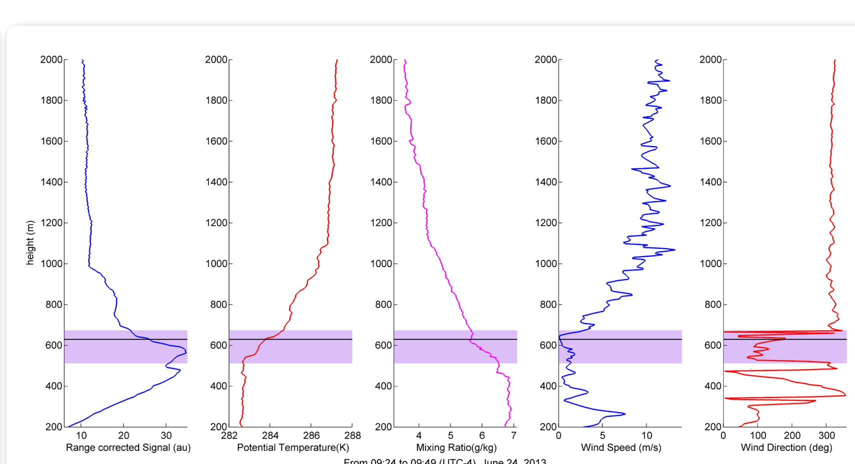

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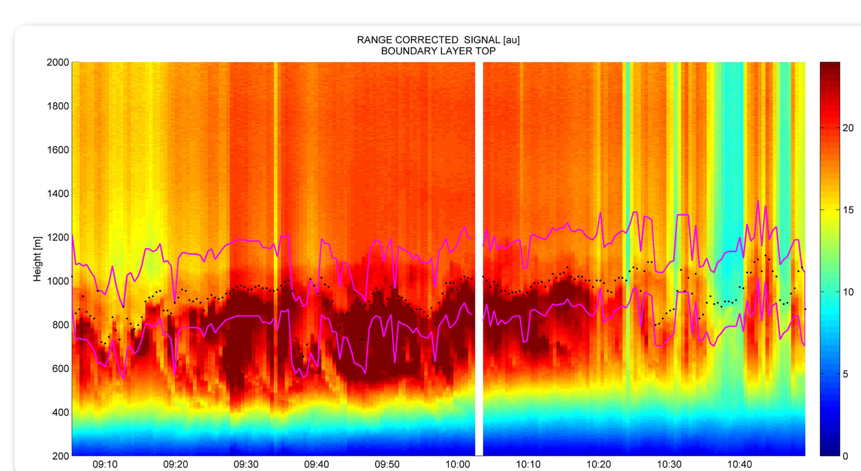
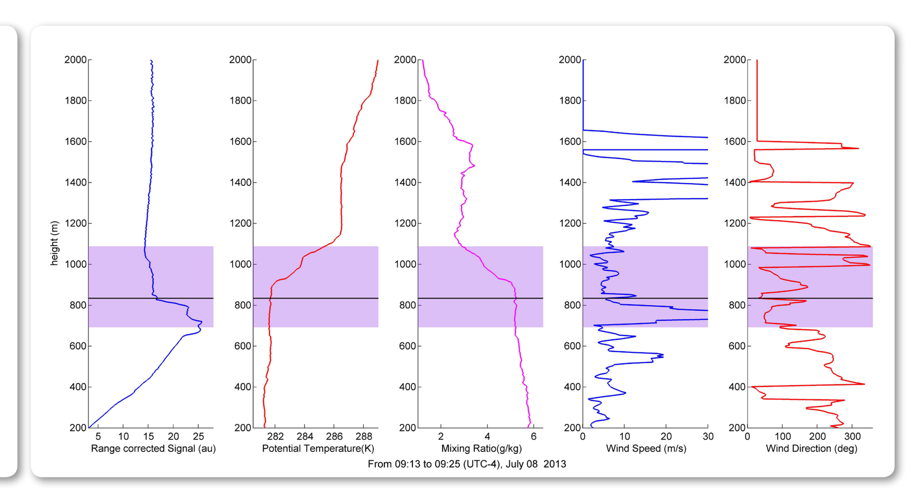

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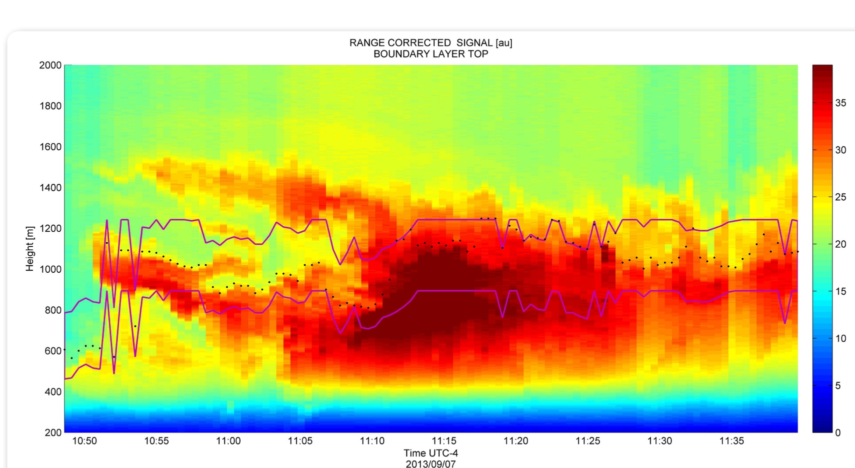
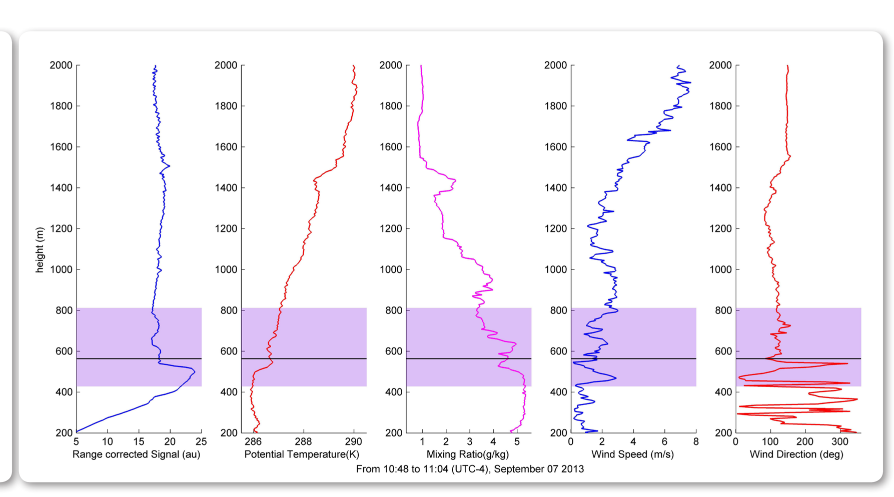

(September 07th)

Figures: Application of the algorithm used to estimate the ABL top with the Haar wavelet transform. This algorithm was applied to a set of profiles taken during 2013 over La Paz city. Data collected for April 29th, May 27th, June 24th, July 08th and September 07th (left) with the morning evolution of the ABL top (represented by the black dots) and its corresponding TZ limits (lines in purple). (Right) Comparison between among backscattered lidar signal with meteorological profiles from radiosondes with height of the ABL top (in black line) and its corresponding TZ limits (shadow in purple).

Results and Conclusions

Based on lidar profiles taken between April and September of 2013 the ABL top is, in average, at a height of 800 ± 300 m in the morning when stable conditions are usually present. Cases were convective activity is strong during morning periods are not considered for this calculation.

The behavior of meteorological parameters obtained by radiosoundings agree with the behavior expected around the TZ (i.e. winds much more variable within the ABL than at the free troposphere) for days when convective activity is not strong at mornings.

FUTURE WORK

More data is needed in order to understand the daily behavior of the ABL thickness over La Paz city. For that purpose various campaigns will be performed, especially for afternoon, evening and night periods, with lidar and radiosounding simultaneously. This will allow us to study the behavior of the ABL along the day in order to characterize it during periods with strong convective activity (typically associated with solar radiation reaching the surface).