Could LIDAR methods Automatically detect the top of ABL? – Case studies for Santa Maria/CHUVA-SUL

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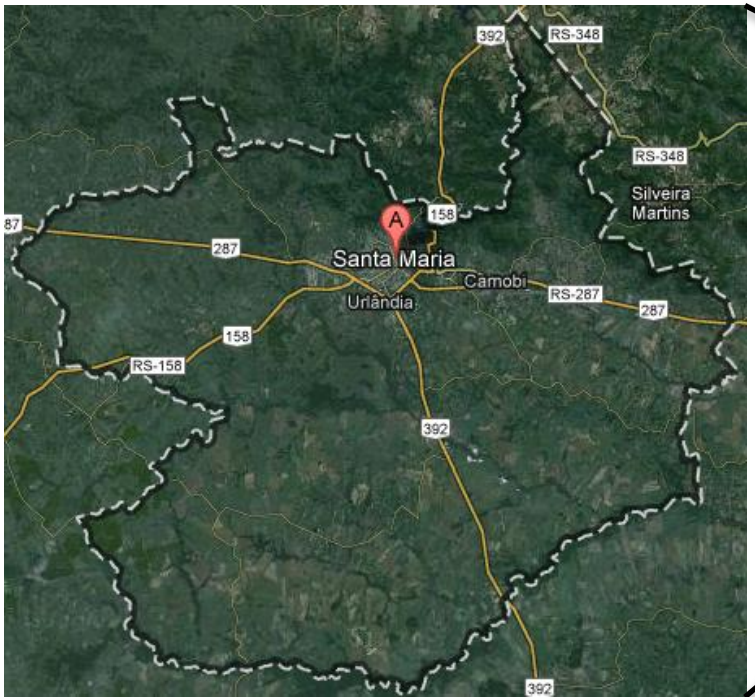
Introduction

Experimental Site:

Santa Maria – Rio Grande do Sul – Brazil
(-29.6,-53.8)



Campaign:
CHUVA-SUL 2012

Objective

The objective of this work is to perform a comparison of the behavior of three algorithms:

- Gradient Method,
- Wavelet Covariance Transform and
- Richardson's Number

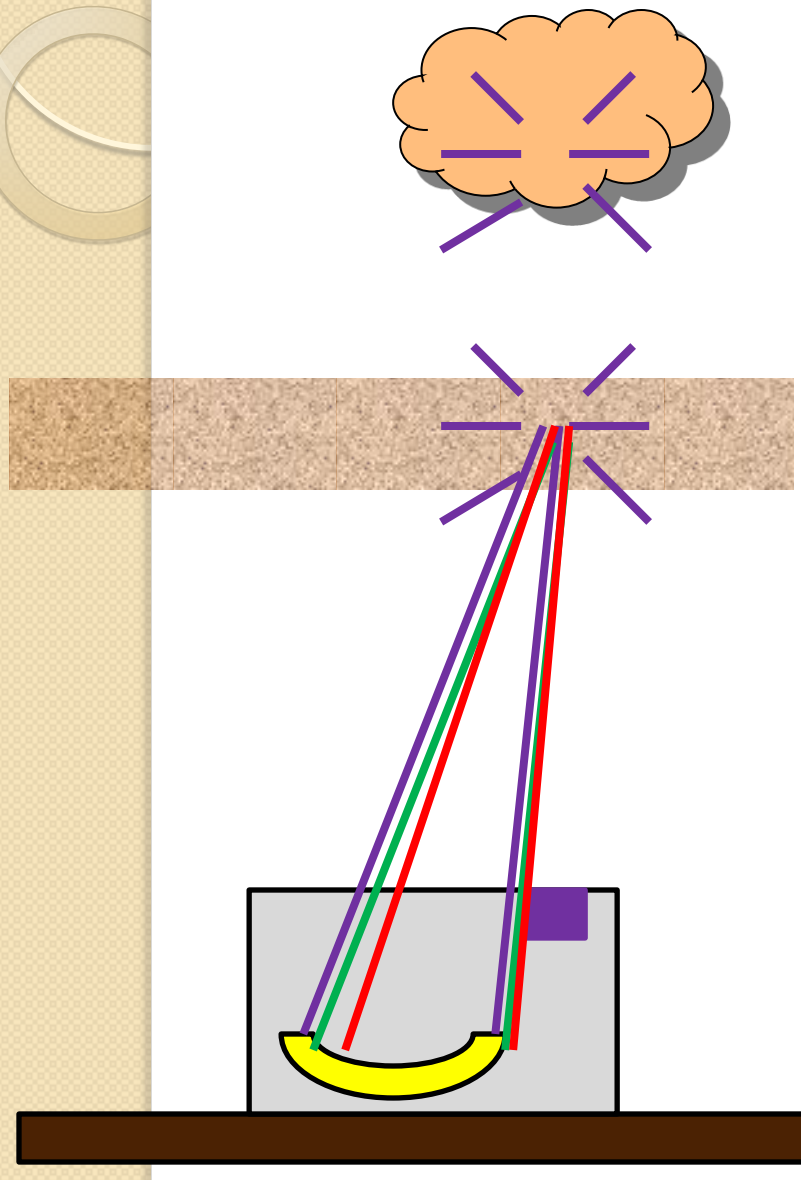
Retrieving the height of the PBL and verify their performance on different atmospheric conditions.

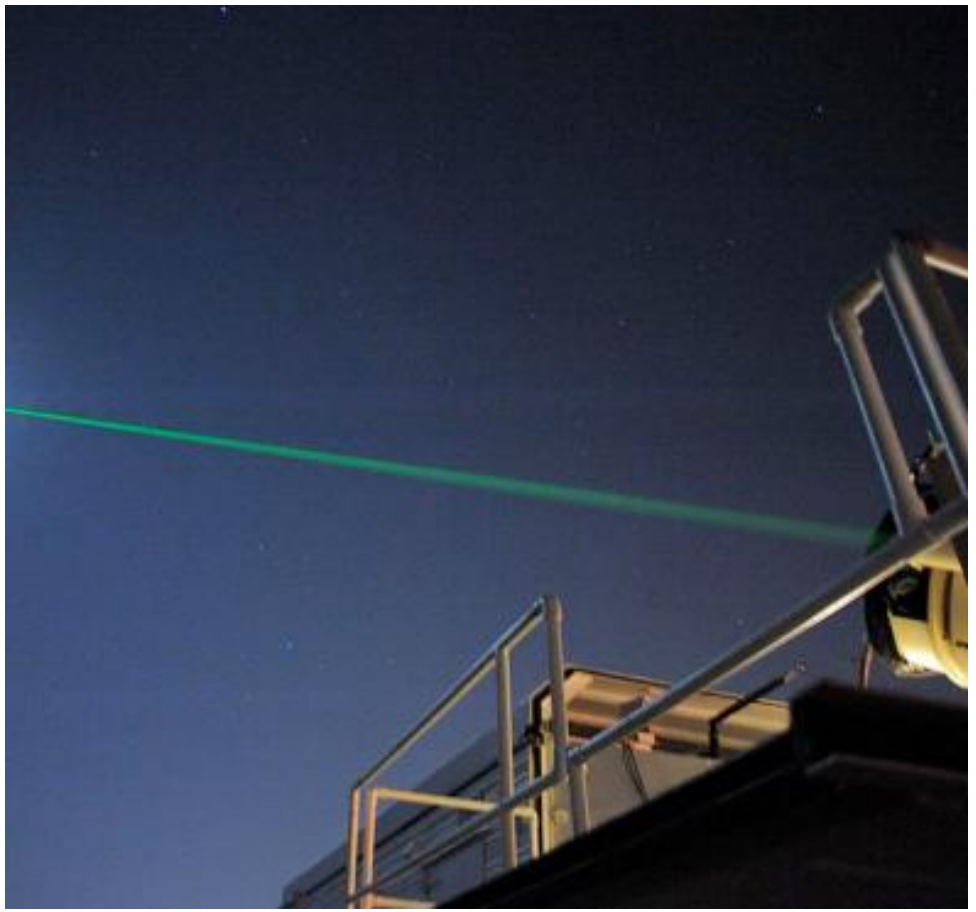
Instrumentation

Mobile LIDAR System

Developer: Raymetrics
Laser: Nd:YAG model CFR 200
Wavelength: 532 nm
Telescope: Cassegraniano 200mm de diameter

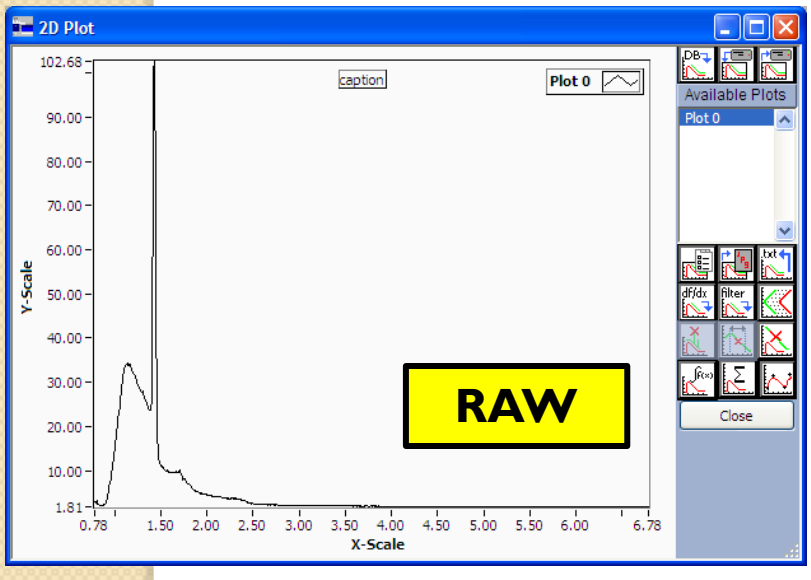
Lidar





Lidar Equation

$$P(z,\lambda) = \underbrace{P_0 \frac{c \cdot \Delta T}{2} A_{telescope} \eta_{eff}(\lambda) \frac{O(z)}{z^2}}_{\text{instrument}} \cdot \underbrace{\beta(z,\lambda)}_{\text{Back scatter}} \cdot \underbrace{\exp\left[-2\int_0^z \alpha(z',\lambda)dz'\right]}_{\text{attenuation}}$$



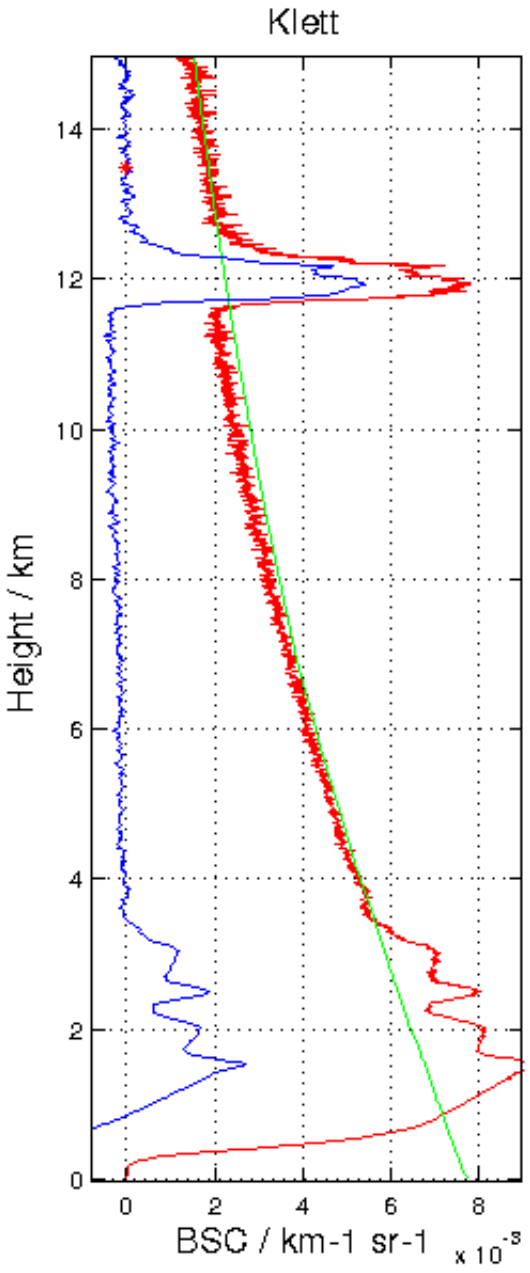
It is possible to invert the equation and determine the back scatter and absorption coefficients

Gradient Method

In this case was used the derivative of logarithm the LIDAR signal ($P(z)$) corrected with the square of height ($P(z).z^2$):

$$\frac{d}{dz} log(P(z).z^2)$$

which minimum value is the top of ABL



Wavelet Covariance Transform (WCT)

This method consists in detection of change in range-corrected signal by the realization of the covariance (W_f) between the wavelet function (in this case Haar function - $h\left(\frac{z-b}{a}\right)$) and the LIDAR signal corrected with the height ($P(z).z^2$).

$$W_f(a,b) = \frac{1}{a}\int_{z_b}^{z_t}(P(z).z^2).h\left(\frac{z-b}{a}\right)dz$$

where b and a are the vertical translation and dilatation of function, z is the height, z_b and z_t are the boundaries of the low and high profile, respectively.

The point where the function has its maximum corresponds to the top of ABL.

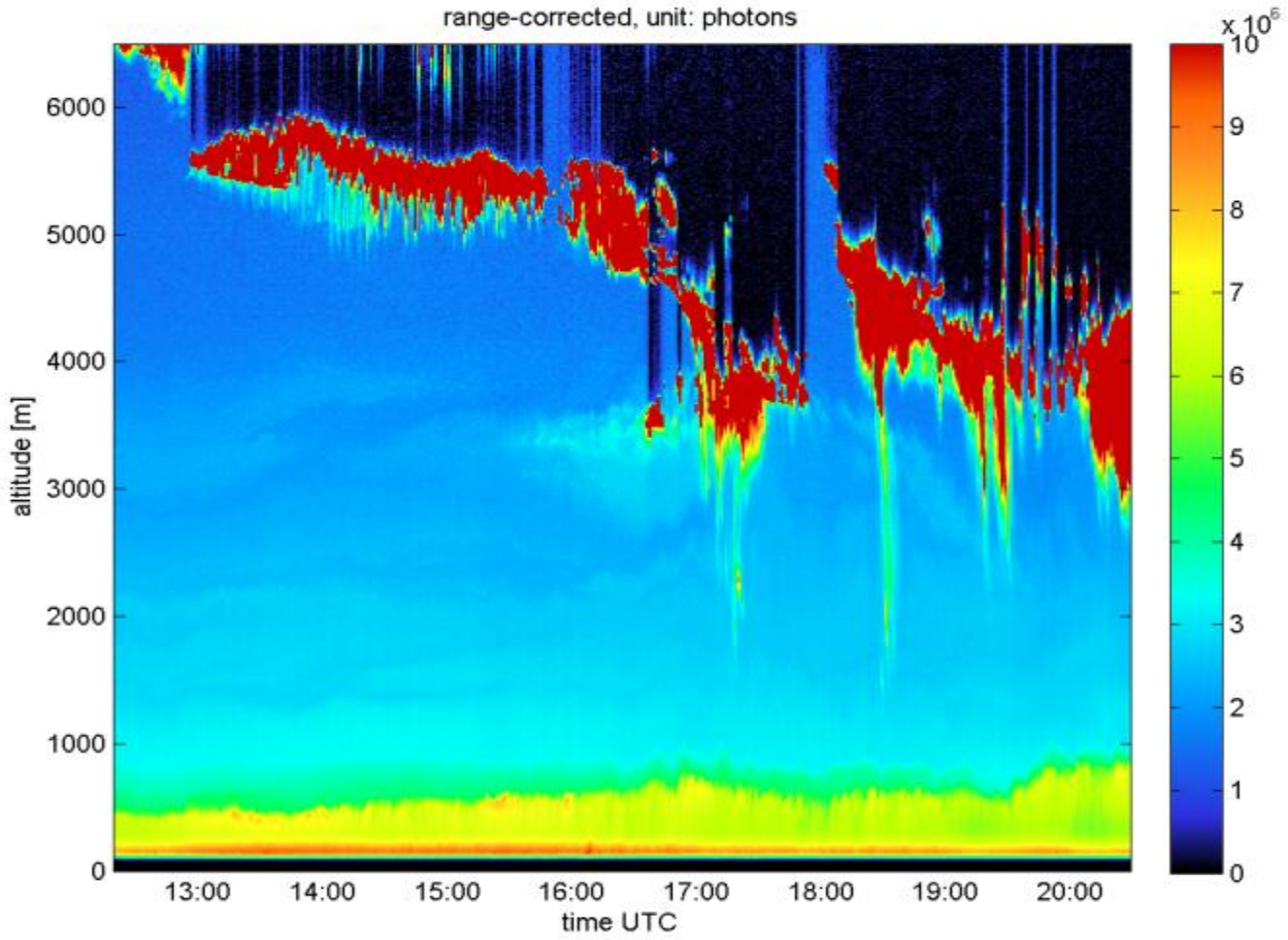
Richardson Number

This method was used for validation because it is obtained from radiosounding data.

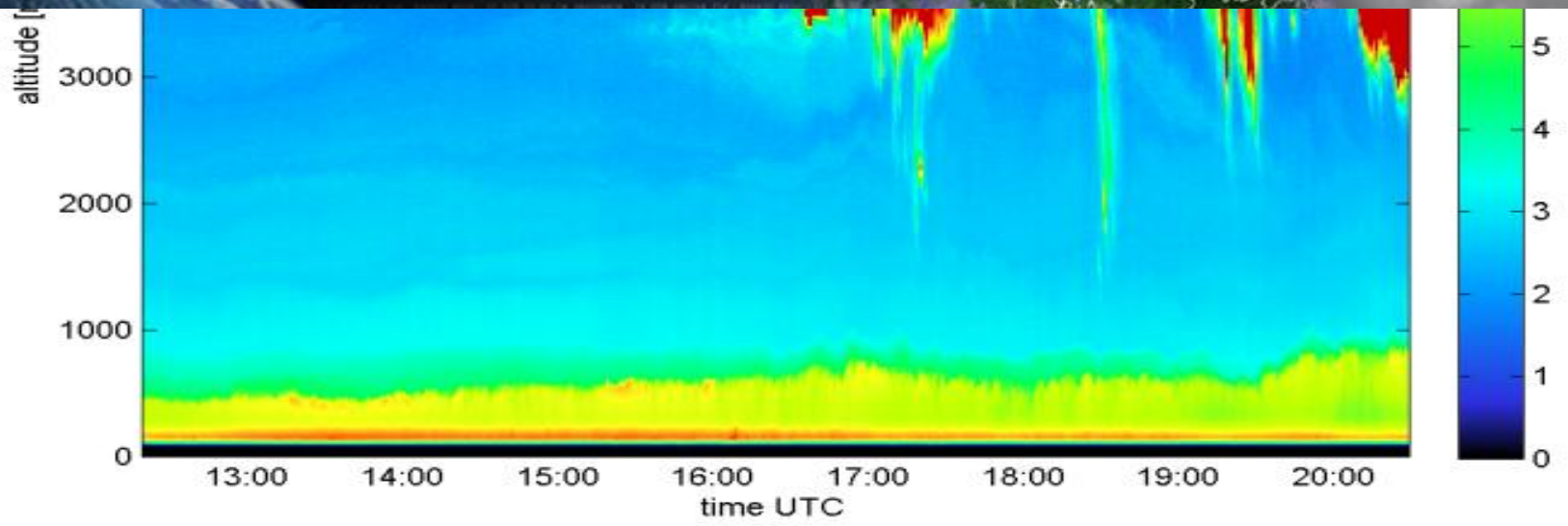
$$R_{bs} = z \frac{g}{\theta_{average}} \frac{[\theta(z) - \theta_s]}{U(z)^2}$$

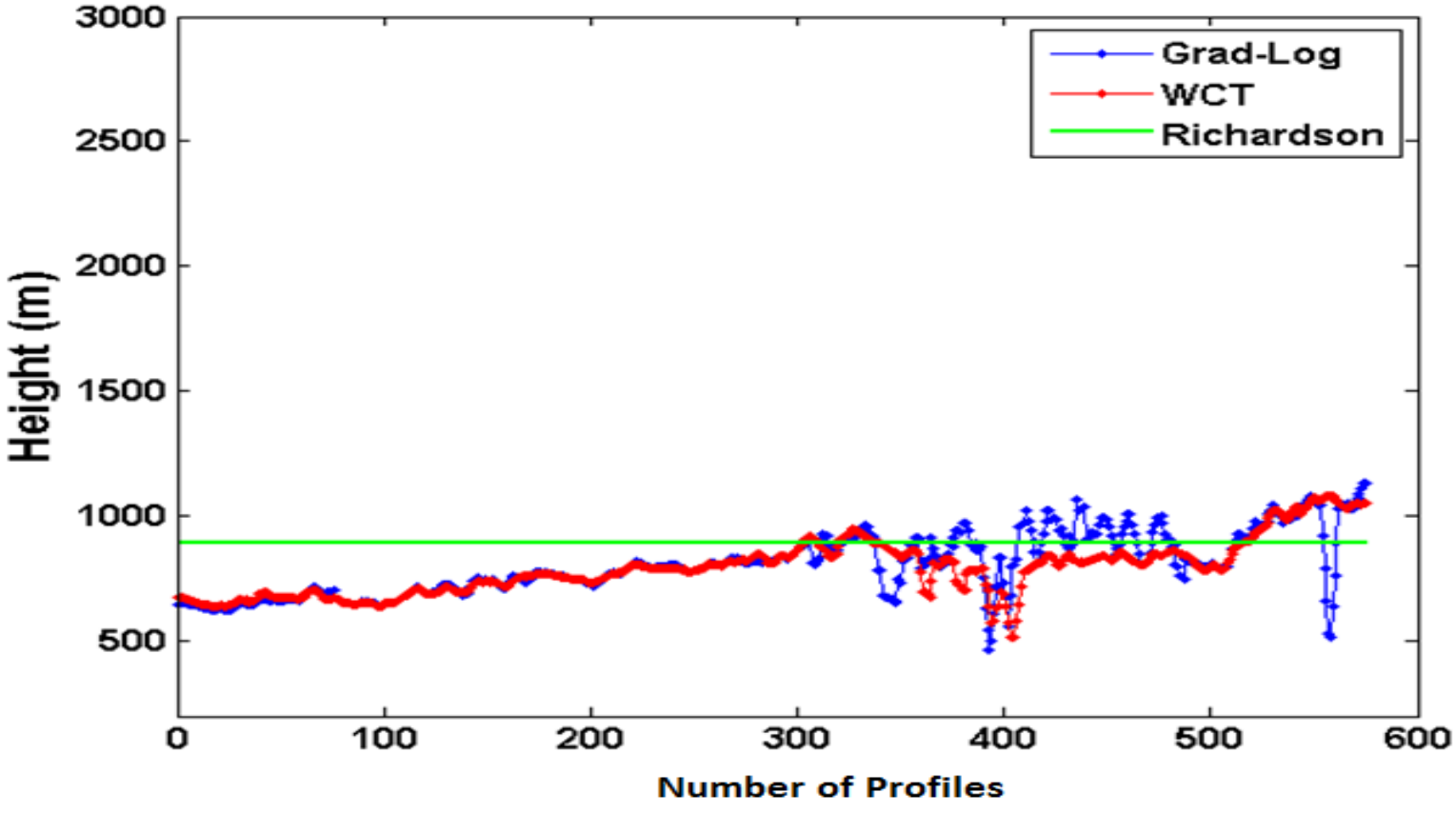
where: **z** is the height, **g** is the value of gravity, $\theta_{average}$ is the average value of potential temperature of layer, $\theta(z)$ is the potential temperature in z point, θ_s is the potential temperature at ground level and **U(z)** is the wind speed at the altitude z. The altitude of the top of PBL is the first point where R_{bs} is below 0.25.

Cases Study: Stable Conditions

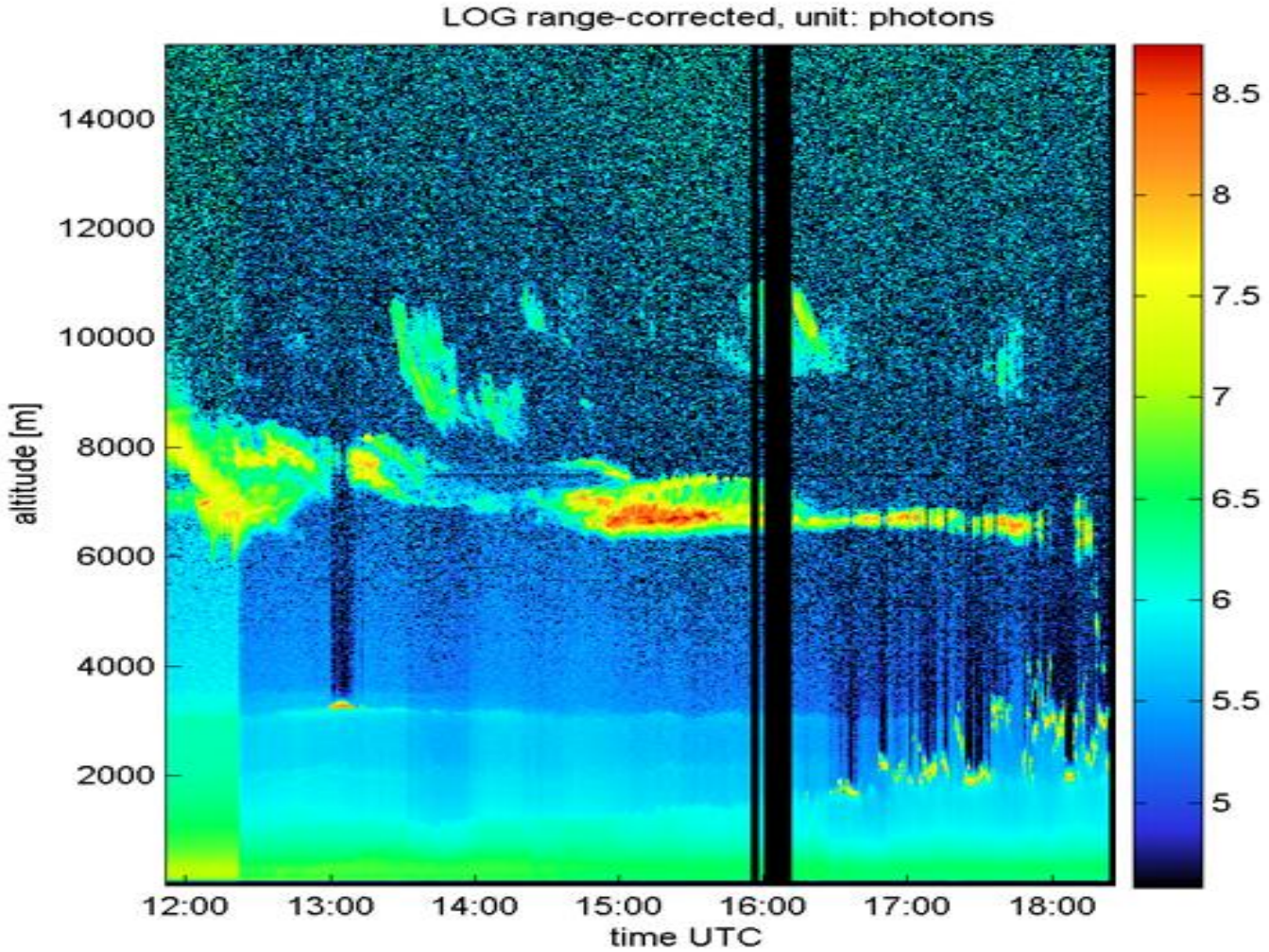


Profile LIDAR

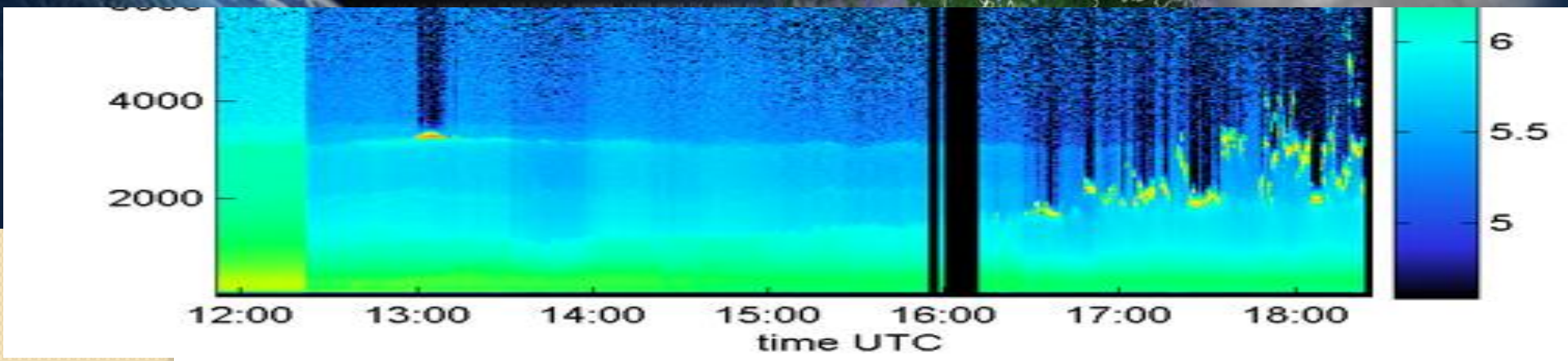

altitude
3000
2000
1000
0
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
time UTC
5
4
3
2
1
0

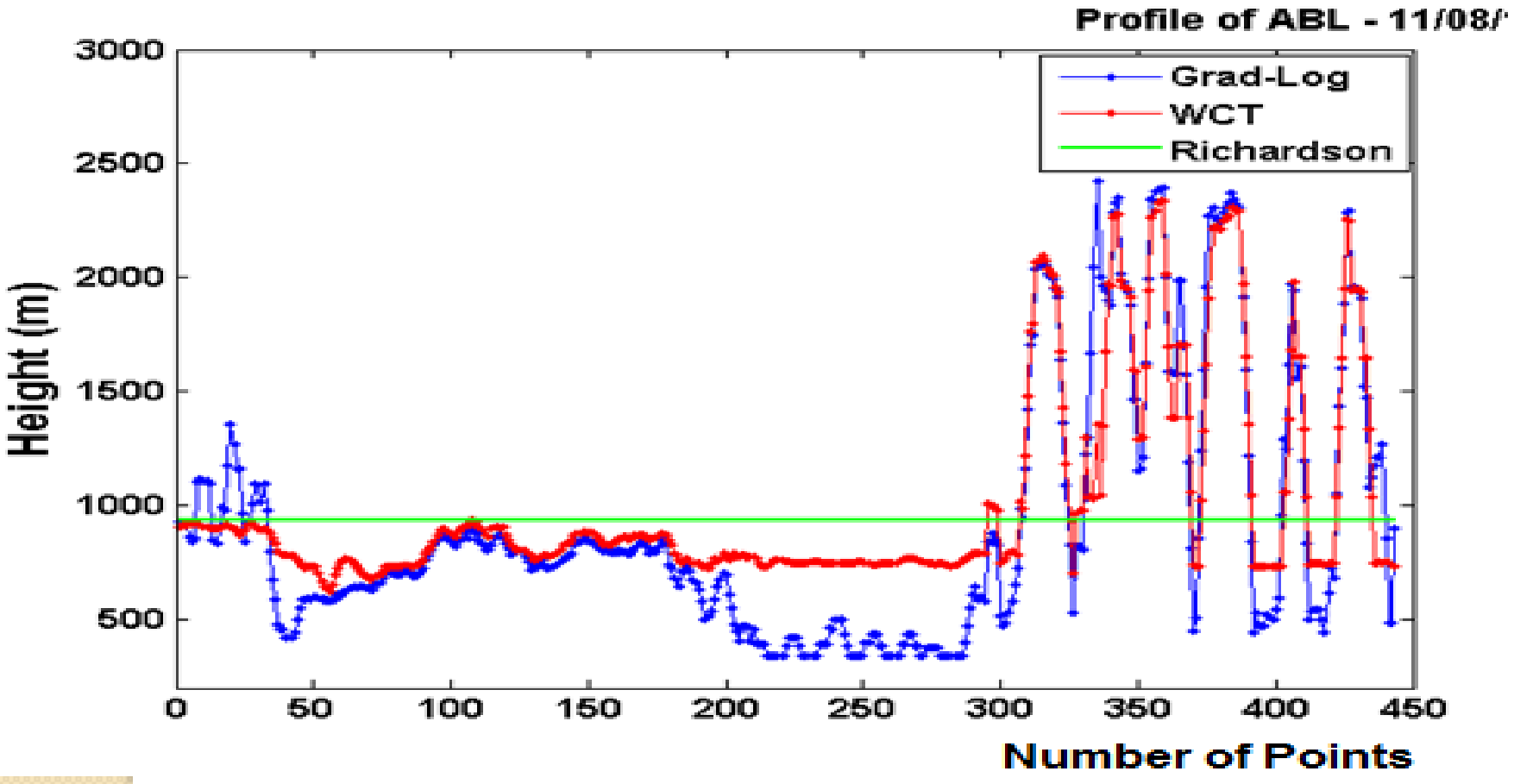

Grad-Log
WCT
Richardson
Height (m)
3000
2500
2000
1500
1000
500
0
100
200
300
400
500
600
Number of Profiles

Day with Sublayers

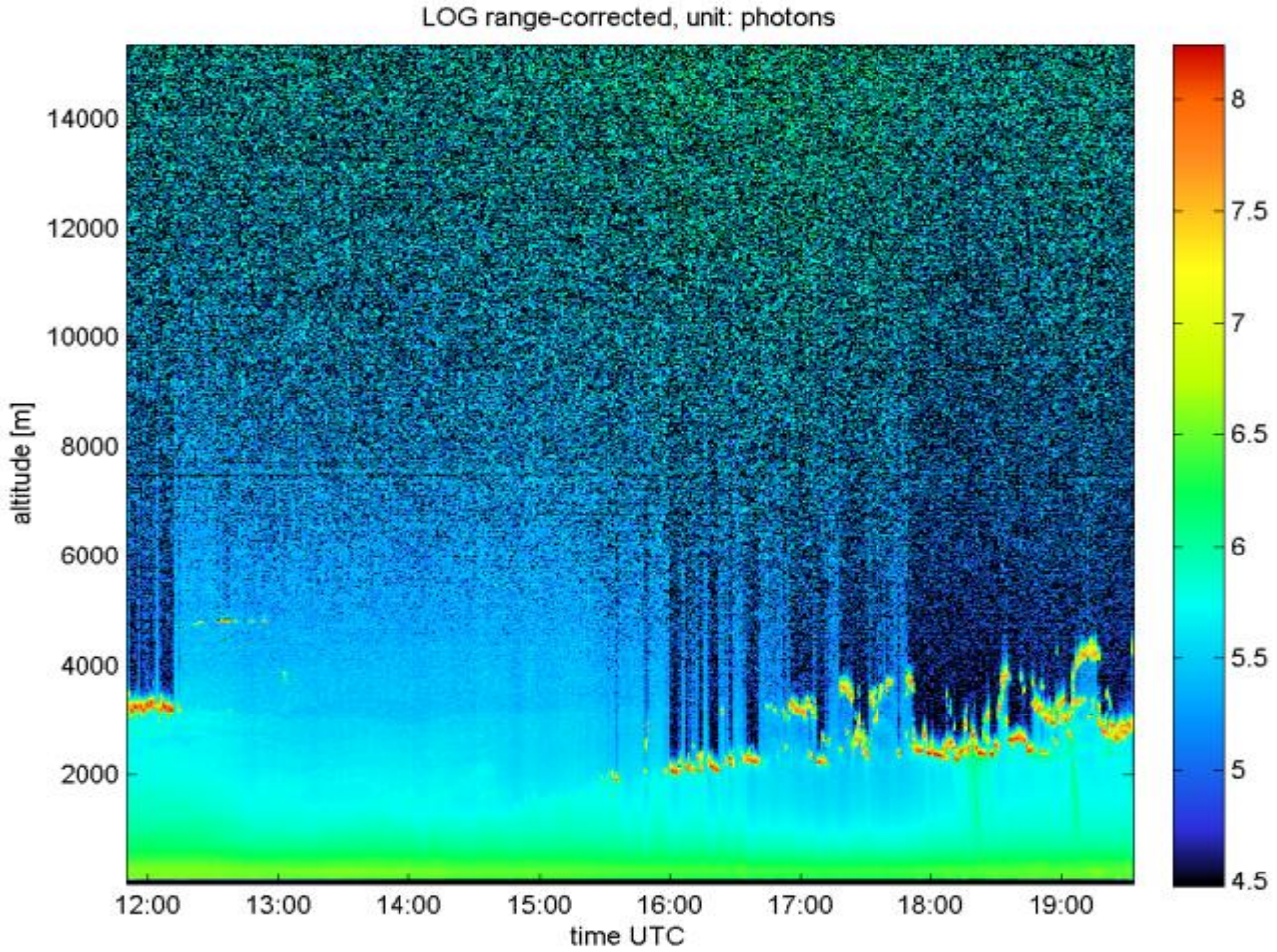


Profile LIDAR

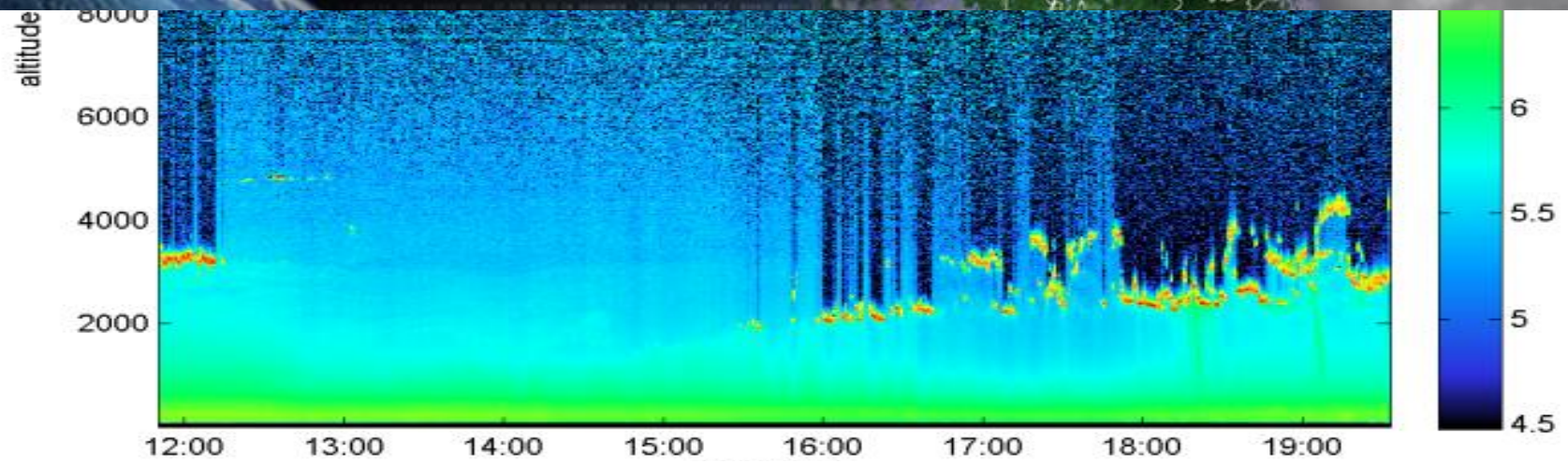

4000
2000
6
5.5
5
12:00
13:00
14:00
15:00
16:00
17:00
18:00
time UTC

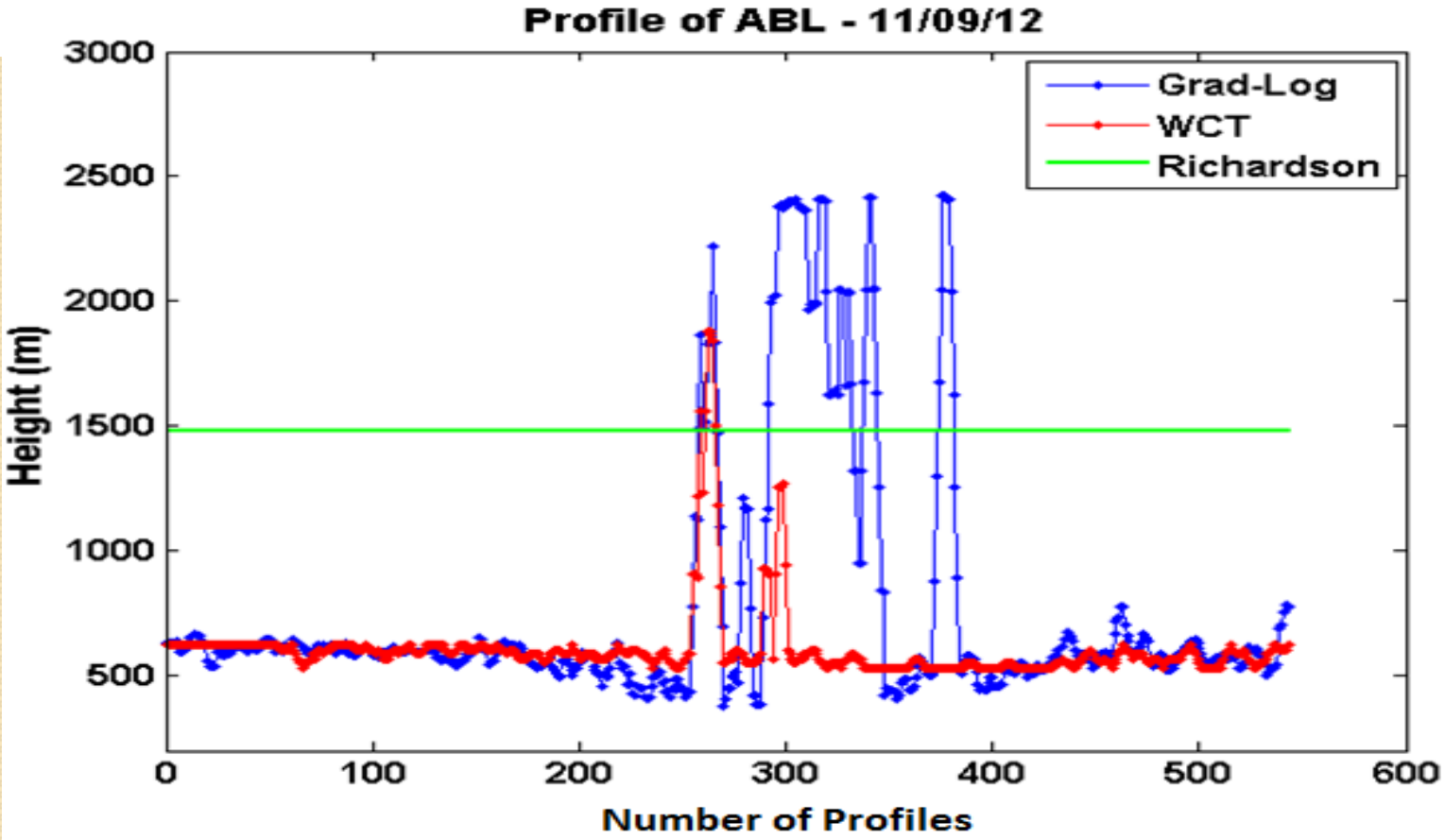

Profile of ABL - 11/08/
Grad-Log
WCT
Richardson
Height (m)
3000
2500
2000
1500
1000
500
0
50
100
150
200
250
300
350
400
450
Number of Points

Turbulent Day



Profile LIDAR


altitude
6000
4000
2000
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
6
5.5
5
4.5


Profile of ABL - 11/09/12
Grad-Log
WCT
Richardson
Height (m)
3000
2500
2000
1500
1000
500
0
100
200
300
400
500
600
Number of Profiles

Conclusions

- **GM and WCT retrieved PBL heights within the range of RN. It was also observed that in cases of cloudiness or in the presence of sublayers, their performance is reduced or deceiving;**

- **For turbulent days, the choice of the parameters appears to be critical;**

Thanks!!