1. Introduction.

The importance of measuring the depth of the atmosphere’s convective Planetary Boundary Layer (PBL) is well recognized in air quality monitoring and prediction studies, including its use in both initialisation and evaluation of numerical weather prediction models. A previous study (Bianco and Wilczak, 2002) has shown success in determining the convective boundary layer depth with radar wind-profiling radars using fuzzy logic methods, and here we discuss improvements to our earlier work. The improved method first applies a post-processing method to get a better determination of the atmospheric signal in radar spectra (the post-processing software used for this purpose is the Vaisala Multi Peak Procedure –MPP– rather than the Fuzzy Logic procedure used before –FL–, but in a comparative analysis also the Vaisala Single Peak Procedure –SPP– is involved); the method then applies fuzzy logic techniques to calculate the depth of the convective boundary layer. The fuzzy logic technique for the computation of the boundary layer depth is improved with respect to the one used in the previous study in that it adds information obtained from the small scale turbulence (vertical profiles of the spectral width of the vertical velocity) while also still using vertical profiles of both the radar-derived refractive index structure parameter $C_n^2$, and the variance of vertical velocity. As an additional and optional step, a temporal continuity test, over a period of one day, can be performed on the boundary layer depth estimations, to improve the results of the analysis. In order to test how the new algorithm performs compared to the previous one and to other procedures, we have selected 2 datasets of spectral data, collected from sites located in Pittsburgh (Pennsylvania) – PIT, and Plymouth (Massachusetts) – PYM. These two sites, one inland and one coastal, were chosen because of their different boundary layer characteristics. Data were collected in 2004 from July to September, giving a total of ~100 profiler days for analysis. A comparison with independent boundary layer depth estimations, made “by-eye” by experts at the two radar wind profiler sites, shows that the new improved method gives significantly more accurate estimates of the boundary layer depth than does the previous method, and also much better estimates than the simpler “standard” method of selecting the peak of $C_n^2$ (which usually has a local maximum at the inversion due to small-scale buoyancy fluctuations associated with the entrainment process).

2. Data analysis.

First, we tested the use of the MPP post-processing procedure compared to other methods. For this purpose the three spectral post processing methods taken under consideration are:

- **SPP**: Standard processing method used in the Vaisala wind profiler software LAP-XM (Vaisala Single Peak Procedure). The SPP method detects and differentiates clutter and atmospheric spectral peaks using the technique fully described in Riddle and Angevine (1992), which attempts to remove ground clutter, but not radio frequency interference or point target clutter.

- **FL**: Fuzzy Logic procedure utilized in the previous work (Bianco and Wilczak, 2002). The FL method, fully described in Bianco and Wilczak (2002), applies fuzzy logic methods for the signal peak and clutter identification.

- **MPP**: Vaisala Multi Peak Procedure, fully described by Griesser and Richner (1998), is an alternative processing method commercially available in Vaisala wind profiler software.

Second, we tested the improved fuzzy logic algorithm for the PBL depth estimation compared to the previous one. Particularly, we looked at the performances provided by the integration in the fuzzy logic procedure for the PBL depth...
estimation of the vertical profiles of the spectral width of the vertical velocity, while also still using vertical profiles of both the radar-derived refractive index structure parameter $C_n^2$, and the variance of vertical velocity. Three different procedures for the PBL depth estimation were tested. They are:

- **BLFL1**: a standard Boundary Layer depth algorithm that is similar to that of Angevine et al., 1994 in that it relies solely on the maximum of the $C_n^2$ profile. It can be considered a fuzzy logic algorithm using only 1 input.
- **BLFL2**: the previous approach that uses vertical profiles of both the radar-derived refractive index structure parameter $C_n^2$ and the variance of vertical velocity as introduced in Bianco and Wilczak, 2002. It is a fuzzy logic algorithm which uses 2 inputs.
- **BLFL3**: an improved method that adds information obtained from vertical profiles of the spectral width of the vertical velocity while also still using vertical profiles of both the radar-derived refractive index structure parameter $C_n^2$, and the variance of vertical velocity. It is a fuzzy logic algorithm which uses 3 inputs.

The computation of the PBL depth for any hour of the data sets was computed in different ways. We combined the three methods for the moments' estimation with the three different procedures for the PBL depth estimation introduced above. Here we show the results from the MPP-BLFL3 method only, which uses moments computed after post-processing the spectral data with MPP, and the improved fuzzy logic method, BLFL3, for the estimation of the PBL depth.

### 3. Conclusions.

The combination MPP-BLFL3 has been found to give the best results when compared to the 8 other possible combinations of spectral processing and boundary layer depth algorithms. The new method MPP-BLFL3 gives an absolute error of the mixing-depths comparable to the vertical range resolution of the profilers. Figure 1 shows the results obtained with the improved algorithm (MPP-BLFL3) compared with the PBL depth evaluations obtained by the expert estimations for the two sites. The left panel shows data from Pittsburgh and right panel from Plymouth. The improved algorithm outperformed the other methods, the results of which are not presented here, even if it still leaves a couple of outliers per site (in figure 1 identified with the circles).

![Fig. 1](image)

Fig. 1. Scatter plots of PBL depth estimations from the MPP-BLFL3 method vs. PBL depth estimations made “by-eye” by the experts. Left: Pittsburgh site; right: Plymouth site.

### References.


