ABL height different estimation by Lidar in the frame of HyMeX SOP1 Campaign

D.Summa[1,2], P.Di Girolamo[2], G.Vivone1, G.D'Amico[1], and N.Franco[2]
[(1)]CNR-IMAA C.Santa Loja Tito Scalo (Potenza), Italy
[(2)] University of Basilicata, via Ateneo Lucano, Potenza Italy

INTRODUCTION

This work stems from the idea of improving the study and characterization of PBL at high resolution and in unstable weather conditions, characterized by strong turbulence and precipitation. A new approach based on the rotational temperature signals of a Lidar system (BASIL) is used for the characterization of the PBL in the lower troposphere. The elastic signals at wavelength 532 nm and pure rotational Raman signals (strongly dependent on temperature variation) of 355 nm are considered. In particular, the case study considered to evaluates the PBL in period of HyMex campaign and in particular form 16th to 21th October 2012. The result was compared with other innovative methods such as the recently published named MIPA and for others traditional methods such as those obtained by Radiosounding and water vapour. For each type of methodology applied a statistical analysis of the data is carried out.

BASIL SYSTEM

For the specific operation of HyMeX-SOP1, the laser source was upgraded to generate a single pulse energy power at 355 nm of 500 mJ (corresponding to an average power of 10 W at a pulse repetition frequency of 20Hz). The received is developed around a Newtonian telescope, with a primary mirror diameter of 0.45 m. The receiver also includes two small lenses, with a diameter of 0.05 m, these latter two used for the collection of the 532 and 1064 nm elastic signals. The key feature of BASIL is represented by its capability to perform daytime and night-time high-resolution and accurate measurements of atmospheric temperature and water vapour based on the application of the rotational and vibrational Raman lidar technique, respectively.(Di Girolamo et al., 2016)

Rotational Raman signals can potentially be used to infer both the mixed layer and the residual layer height. In this respect, we need to recall that temperature measurements are performed by BASIL through the application of the rotational Raman lidar technique in the UV.

These same rotational signals can be used to determine the ABL height (Summa et al., 2013)

The ratio **R(z)= P_{HiJ} (z)/ P_{LoJ} (z)** is characterized by a strong sensitivity to temperature variations, therefore we can analyze minimum of the derivative for the range corrected signals

$$RCS(z)=R(z)z^2$$

in the follow algorithm to determine the height of the ABL:

$$ABL = \frac{d}{dz}\{\log RCS(z)\}$$

The integrated analysis with all the ERA5 parameters show that friction velocity is the main driver of the PBL variability in presence of an approaching lower pressure system while surface temperature determines the remaining variability.

Methodology and Results

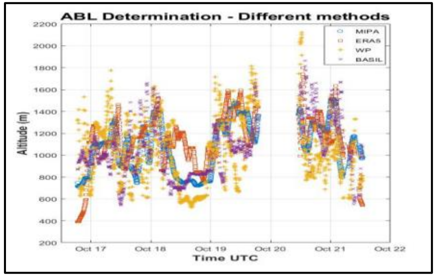
THE MIPA FRAMEWORK

Morphological Image Processing Approach (MIPA) framework used to detect the ABL when lidar data are involved. These latter can be represented as an image of range corrected vertically-resolved profiles acquired sequentially in time. MIPA consists of four main blocks: i) a vertical spatial resolution adjustment step to reach a (target) working spatial resolution (around 20 m); ii) a pre-processing based on mathematical morphology; iii) an edge detector (i.e., the Wavelet Covariance Transform (WCT) [2] in this work); iv) a post processing relied upon both mathematical morphology and an object-based analysis to get the final result. It is worth to be remarked that MIPA is a blind approach and, thus, it does not exploit any prior information.

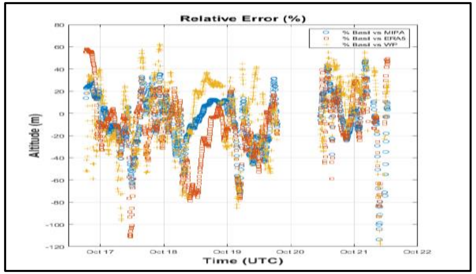
Algorithm 1 The MIPA framework.

- Vertical spatial resolution adjustment of $\mathbf{I}$ by a factor R to get $\mathbf{I}_D$
- Pre-process $\mathbf{I}_D$ by low-pass filtering using half-gradients to get $\mathbf{I}_{pre}$
- Detection of the edges of $\mathbf{I}_{pre}$ using the WCT to get the edge map $\mathbf{E}$
- Post-process $\mathbf{E}$ using directional morphological filters and an object-based analysis to get $\mathbf{E}_{out}$

The results from the Raman lidar are compared with a Wind Profiler, with ECMWF-ERA5 reanalysis, with MESO-MH mesoscale forecasts, and also with the MIPA methodology. The figures below reports the percentage deviations between BASIL and the other methodologies/sensors/models, which are found to always be within ±50%.

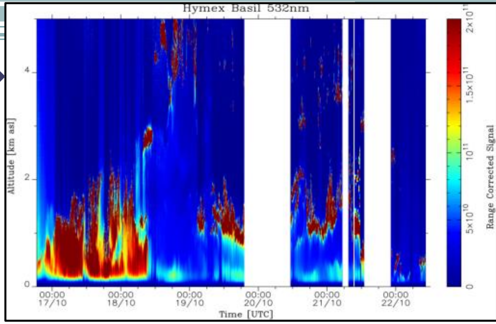


ABL Comparison in terms of ABL estimates from different approach during the period 16-21 October 2012



Percentage deviations between BASIL and the other methodologies/sensors/models during the period16-21 October 2012

Map of RCS Elastic signals (532nm) relating to the measurement campaign for the period 16-22 October 2012



ACKNOWLEDGMENTS

Wind Profiler dataset were obtained from the HyMeX program, sponsored by Grants MISTRALS/HyMeX and ANR-11-BS56-0005 IODA-MED project.(Contact person: Said Frèdèrique Laboratoire d'Aérologie, Université de Toulouse, UMR CNRS 5560).