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Scuola di Ingegneria

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ABL DETERMINATION BY RAMAN LIDAR WITH DIFFERENT APPROACHES IN THE FRAME OF HYMEX SOP1

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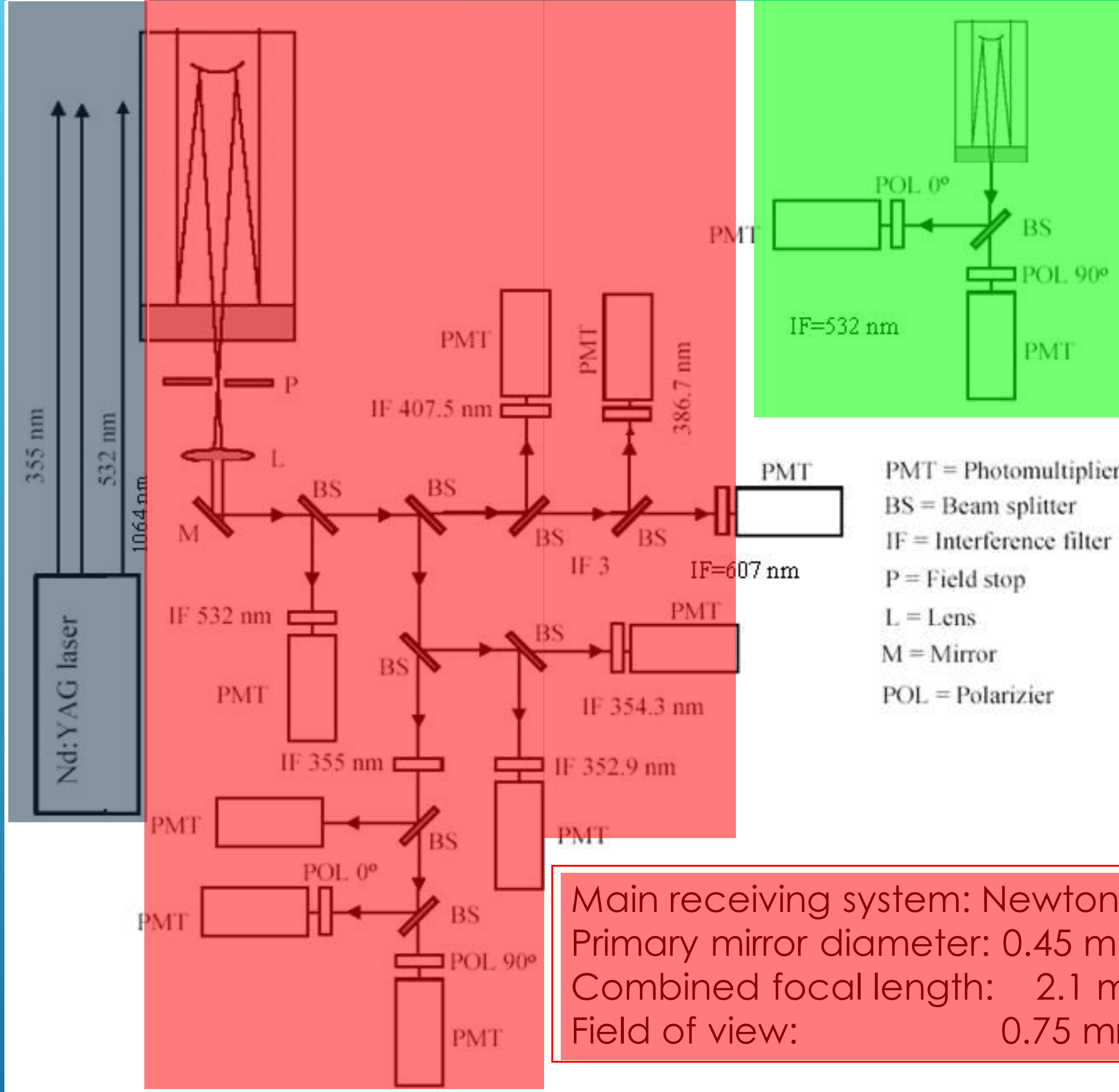


Nd:YAG Quanta Sys.-SYL202)
355, 532, 1064 nm
Laser pulse repetition rate: 20 Hz
Single pulse energy:
500 mJ 355 nm (average power: 10 W)
300 mJ 532 nm (average power: 6 W)
400 mJ 1064 nm (average power: 8 W)
...ce 0.5 mrad
5 ÷ 6 ns

Main receiving system: Newtonian telescope
Primary mirror diameter: 0.45 m
Combined focal length: 2.1 m
Field of view: 0.75 mrad

Two small telescopes
Aperture: 0.05 m
Focal length: 0.2/0.6 m
Field of view: 10/3 mrad

SPECTRAL SELECTION: based on Interference Filters

				N_2@355	H_2O@355	N_2@532	Hi J RR	Low J RR
Wavelength (nm)	1064	532	355	387	407	607	354.3	352.9

BASIL Raman Lidar

$3\beta+2\alpha+2\delta+H_2O+T$

Measured parameters:

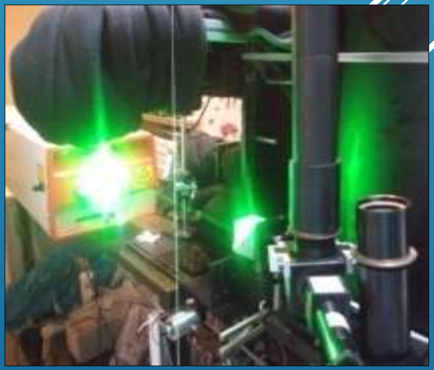
- particle backscattering coeff. @ 355, 532 and 1064 nm [3b]
- particle extinction coeff. @ 355 and 532 nm [2a]
- depolarization ratio @ 355 & 532 nm,
- atmospheric temperature (Rotational Raman technique)
- water vapour mixing ratio (Vibrational Raman technique)
- relative humidity from simultaneous measurements of temperature and water vapour mixing ratio

❑ **Resolution of raw data:**

vertical 7.5 m, temporal 1-10 sec

❑ **Typical resolution of measured parameters:**

vertical 30 m, temporal 1 min



PBl through rotational and water vapour signals gradient

The Range corrected signals is used to create the map of October 16-19 to highlight the structures present in the observation period from BASIL system at wavelength of 532nm.

The RCS can be easily expressed in terms of measured lidar signals taking into account:

$$\mathbf{P_{RCS}(z) = \left[P_{\lambda_0}(z) - P_{bgd}(z)\right]z^2}$$

Where $P_\lambda(z)$ represents the power received at a given wavelength that in our case λ=532 nm

$$\mathbf{P_{RCS}(z) = \frac{P_{HiJ}(z[T])}{P_{LoJ}(z[T])} \cong \exp\,[T(z)]}$$

$$\mathbf{\chi_{H2O}(z) = K\frac{P_{H2O}(z)T_{N2}(z)}{P_{N2}(z)T_{H2O}(z)}}$$

In order to determine an estimate of the height of ABLH, we directly apply the derivative method exploiting the logarithm of the quantity.

$$\mathbf{ABLH = \min\left\{\frac{d}{dz}\left[\log\left(P_{RCS}(z)\right)\right]\right\}}$$

***PBL by MIPA FRAMEWORK* Algorithm**

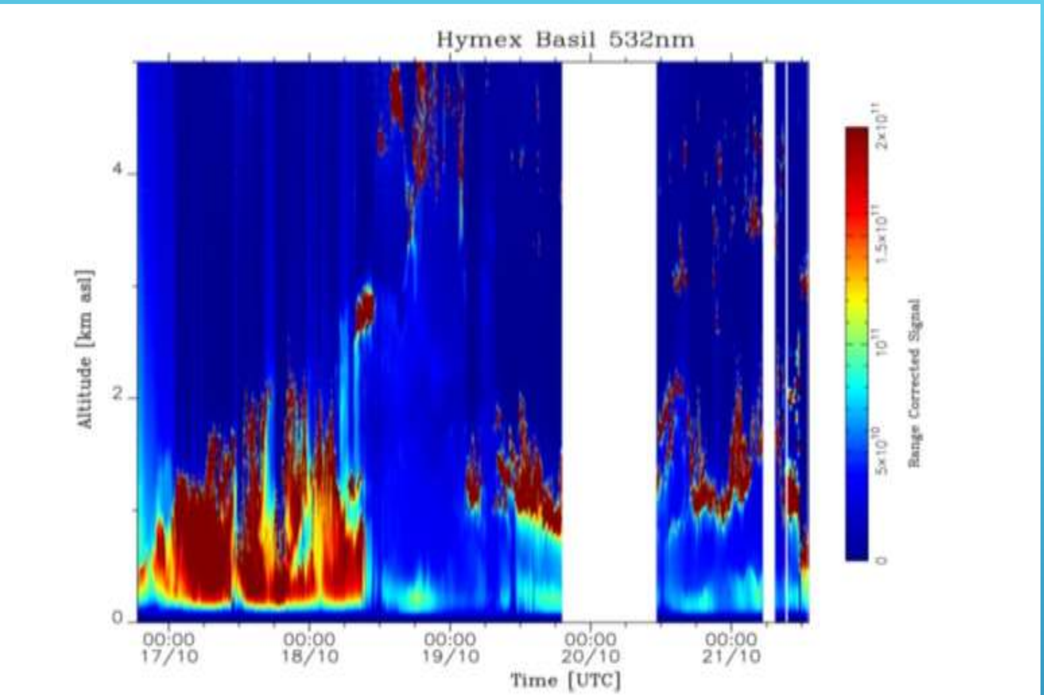
Morphological Image Processing Approach (MIPA) framework used to detect the ABL when lidar data are involved. These latter can be represented as an image of range corrected vertically-resolved profiles acquired sequentially in time. MIPA consists of four main blocks:

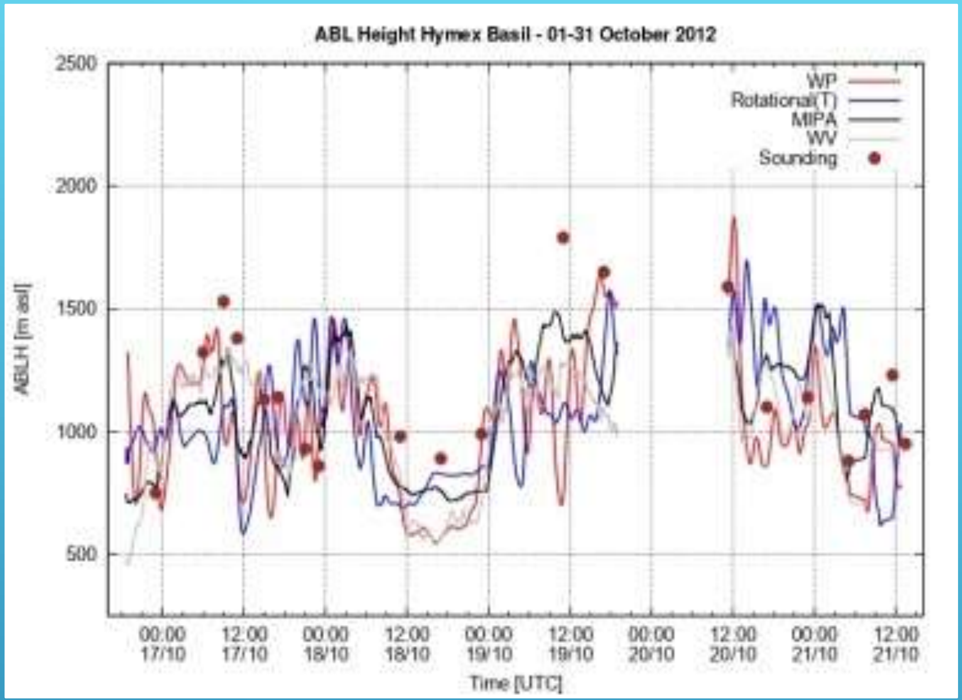
a. a vertical spatial resolution adjustment step to reach a (target) working spatial resolution (around 20 m);
b. a pre-processing based on mathematical morphology;
c. an edge detector (i.e., the Wavelet Covariance Transform (WCT) in this work);
d. a post processing relied upon both mathematical morphology 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.

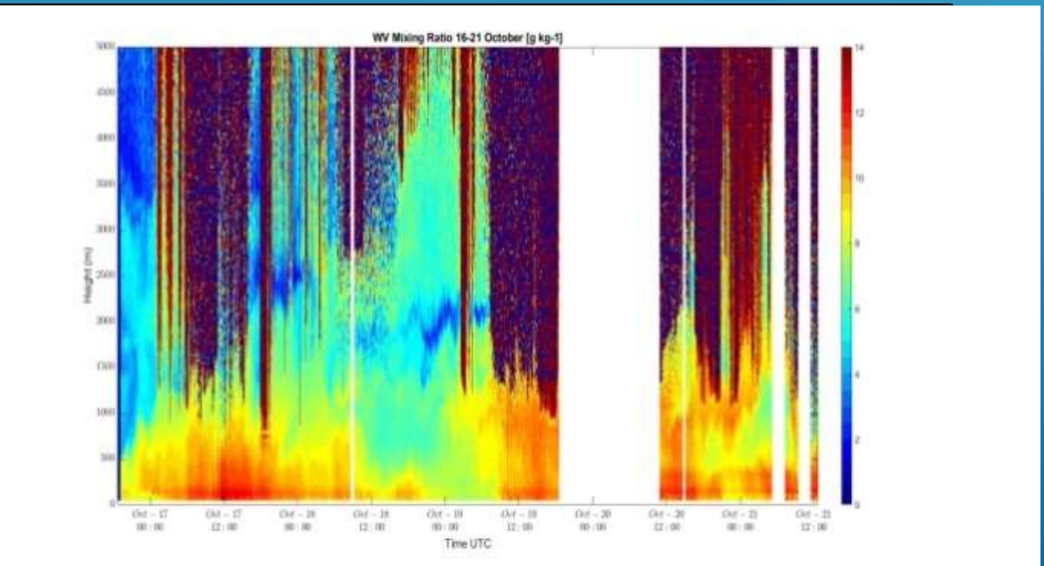
Algorithm 1 The MIPA framework.

- 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 $\mathbf{E}_{out}$

RESULTS:







Methods	MIPA	Rotational(T)	WP	WV
Mean	207.67	281.31	235.68	238.61
Std.dev	127.5	178.9	241.19	144.44
Std.err	29.25	41.04	55.33	33.13
Min	11.81	27.39	27.16	5.15
Max	505.22	591.22	573.62	568.68
I Quartile	132.72	158.82	70.86	127.21
II Quartile	201.25	283.93	167.71	227.72
III Quartile	267.27	379.21	329.09	307.49
IV Quartile	227.31	319.21	309.19	301.39

table of results

COCLUSIONS and future works

- The preliminary results show a good agreement with the different techniques compared with the respective radiosondes placed in the CV-site of the campaign.

- These results are comforting as they allow to study and characterize the PBL even in complex cases with strong convective activity.

References:

- Summa, D.; Di Girolamo, P.; Stelitano, D.; Cacciani, M. Characterization of the planetary boundary layer height and structure by Raman lidar: Comparison of different approaches. Atmos. Meas. Tech. 2013, 6, 3515–3525.
- Madonna F., Summa D., Di Girolamo P., Marra F. ,Wang Y. and Rosoldi M. Assessment of Trends and Uncertainties in the Atmospheric Boundary Layer Height Estimated Using Radiosounding Observations over Europe Atmosphere 2021, 12, 301
- Summa D. et al. Inter-comparison of ABL height estimates from different profiling sensors and models in the framework of HyMeX-SOP1 amt-2021-261

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