Satellite Cal/Val using IPRAL high-performance multi-wavelength Raman Lidar: Heritage from Earlinet research

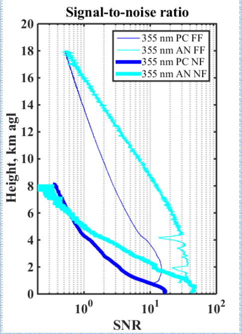
Bravo-Aranda, J. A.; Haeffelin, M.; Piermarini, S. ; Pietras, C.
Contact: jbravo@lmd.polytechnique.fr

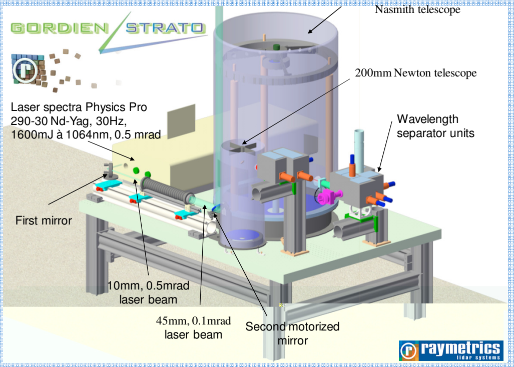
IPRAL's technical specifications

Near and far-field telescope

Near and far-field telescopes and a high laser power improves the signal-to-noise ratio allowing:

- better aerosol optical property retrievals
- reduction of the statistical errors
- **reducing biases between ground-based and satellite measurements distinguishing signal from error bars to lead better satellite cal/val**
- better cirrus and aerosol optical depth measurements to derive satellite optical depths products.

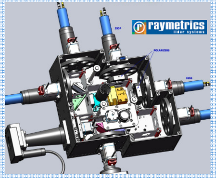


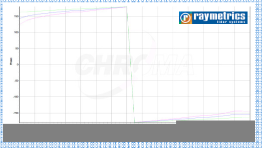


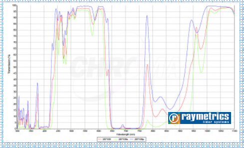
IPRAL's autonomous operation capability (including remote control and automatic safety systems) minimizes operator costs.

Wavelength separator unit

- Interferometers at Raman and elastic wavelengths specially designed for night- and day-time Raman measurements.
- Optical path of the elastic and H2O-Raman channels designed to have the same overlap function.
- Dichroic mirrors designed with no phase-shift and diattenation.





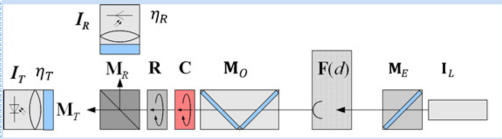


Depolarization improvements

Lidar polarizing sensitivity can drastically affect the volume linear depolarization ration (δ). To determine its influence on depolarization measurements, the δ systematic error ($\Delta\delta$) was quantified using the **Polarimetric Lidar Simulator** based on the Stokes-Müller theoretical basis (see, Bravo-Aranda, 2016 and Freudenthaler, 2016).

lidar systems is subdivided in functional blocks including

- the laser beam (I_L)
- the emitting optics (M_E)
- the receiving optics (M_O)
- calibrator (C),
- the polarizing splitter (M_R and M_T)
- And the received signals (I_R and I_T)



IPRAL signal was simulated according to 12 lidar parameters shown on Table on the right **suitable** behaviour of the **polarizing splitter** is highlighted:

- without cross-talk
- absence of phase-shift
- and low diattenuation of the **receiving optics**.

Functional block	Property			
	Symbol	Name	Value	Error (±)
Laser, I_L	α	Misalignment angle of the laser polarizing plane[1]	0°	2.0°
Steering optics, M_E	D_E	Effective diattenuation	0.00	0.05
	Δ_E	Effective phase shift	0°	180°
	β	Effective misalignment angle[1]	0°	1.0°
Receiving optics, M_O	D_o	Effective diattenuation	-0.012	0.012
	Δ_o	Effective phase shift	0°	-
	γ	Effective misalignment angle[1]	0°	0.5°
Calibrator, C (0-order waveplate in front of splitter)	ε	Misalignment angle[1]	0°	0.1°
Polarizing splitter, M_R and M_T (PBS + polarizers)	Polarizing components		Parallel + perpendicular	
	T_p	Parallel-polarised[1] transmittance	1	-
	T_s	Perpendicular-polarised[1] transmittance	0	-
	R_p	Parallel-polarised[1] reflectance	0	-
	R_s	Perpendicular-polarised[1] reflectance	1	-

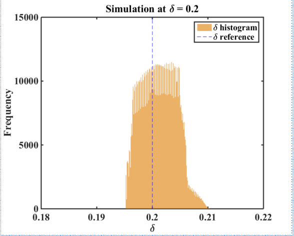
Monte Carlo technique is used to retrieve IPRAL's $\Delta\delta$:

- using Constant Δ_0, D_T and D_R
- parametrizing α, D_E, β, γ, and ε_r using 3 values
- parametrizing D_0 and Δ_E were parameterized using 65 values

$3^5 65^2 \sim 1 \cdot 10^6$ lidar combinations were simulated.

minimum and maximum of the δ histogram lead to $\Delta\delta$.

Table below shows relative systematic error ($\Delta\delta/\delta$) of 16% for $\delta > 0{,}05$.



δ	$\Delta\delta$	$\Delta\delta/\delta$ (%)
0,05	0,008	16
0,1	0,010	10
0,2	0,015	8
0,3	0,019	7
0,45	0,030	6

As ADM-Aeolus and IPRAL measure at 355 nm, the optimal characterization of IPRAL's depolarization provides a suitable framework for satellite cal/val.

Multi-instrumental intercomparison

IPRAL is part of several national (SOERE ATMOS) and international (EARLINET, Pappalardo et al., 2014) lidar networks to perform multi-instrumental cal/val procedure with different aerosol types and under different atmospheric conditions. This networking effort is crucial for:

i) the characterization of the deviation between L2A and ground-based lidar products,
ii) the development of improved processing algorithm based on the characterization of the deviation of the L2A products, and
iii) the exploitation of the long-term space- and ground-based aerosol database.

References

- **Dupont et al.,** Macrophysical and optical properties of midlatitude cirrus clouds from four ground-based lidars and collocated CALIOP observations. JGR, vol. 115, D00H24
- **Pappalardo et al., 2014**: EARLINET, the European Aerosol Research Lidar Network. Atmos. Meas. Tech., 7, 2389-2409, 2014
- **Freudenthaler, 2016**: About the effects of polarising optics on lidar signals and the Δ90-calibration. doi:10.5194/amt-2015-338
- **Bravo-Aranda et al., 2016**: Assessment of lidar depolarization uncertainty by means of a polarimetric lidar simulator. doi:10.5194/amt-2015-339

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And the following organisms: