Aerosol property retrievals toward tropospheric aerosol typing using IPRAL multi-wavelength Lidar and ancillary measurements at the SIRTA observatory

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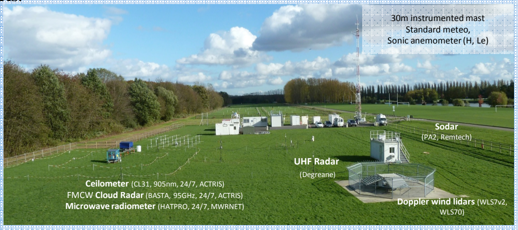
Experimental site

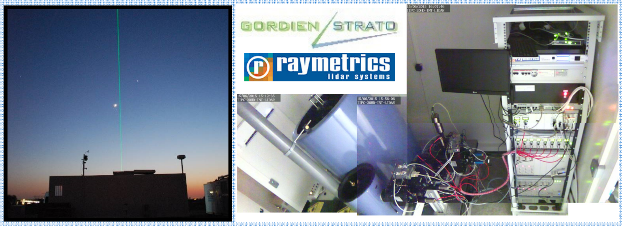
- The **Site Instrumental de Recherche par Télédétection Atmosphérique** (SIRTA) is an atmospheric observatory, located 20 km south of Paris, based on a growing ensemble of state-of-the-art active and passive remote sensing instruments. More than **150 different instruments or sensors** are deployed and continuously monitor the atmosphere during 12 years. SIRTA database collection is daily enhanced by more than 5000 files, making three gigabyte of records.
- The **CNRS-IPSL Hi-Performance multi-wavelengths Raman Lidar,** IPRAL, was designed for multiple objectives: clouds, aerosols, water vapor, boundary layer. Particularly, understanding the air-quality role and aerosol-particle contribution (e.g., anthropogenic, dust, ash, and biomass-burning plumes) in the **megacity of Paris**.

Lidar Haute Performance
IPRAL lidar system (3+3+1) has been designed to provide day-time Raman measurements (N2 and H2O) and high-quality calibrated depolarization measurements.

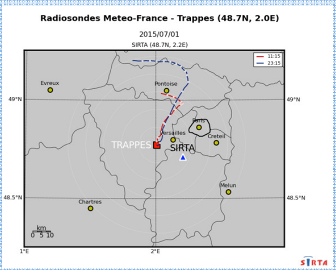


IPRAL technical specifications

- Laser: Nd-YAG (355, 532 and 1064 nm).
- Far-field telescope (3+3+1): 355 (p,s), 387, 408, 532, 607 and 1064 nm
- Near-field telescope (2+1): 355 387, and 532 nm
- Δ90° depolarization calibration
- autonomous measurements and remote supervision



IPRAL water vapor property retrievals



Water-vapor mixing ratio (w) retrieval:

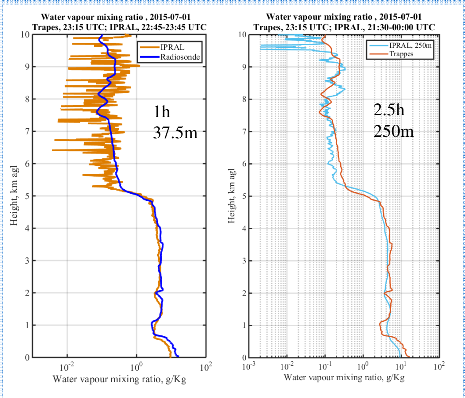
$$w(R) = \frac{P(R,\lambda_{H_2O})}{P(R,\lambda_{N_2})} K \exp\left\{\int_0^R \left[\alpha\left(r,\lambda_{H_2O}\right) - \alpha\left(r,\lambda_{N_2}\right)\right] dr\right\}$$

R: range
$P(R,\lambda)$: lidar raw signal
K : calibration factor
α : extinction coefficient
Assumptions:
1) Identical overlap factors for 387 and 408 nm.

Calibration procedure:
1) Radiosonde at Trappes (15km from SIRTA) with temperature (T) and pressure (P) and $w_{radiosonde}$.
2) T and P profiles to derive the molecular extinction at 387 and 408 nm.
2) Linear fit (2-5 km):
$w_{radiosonde}\ Vs\ \frac{P_{H_2O}}{P_{N_2}} e^{\int_0^R (\alpha_{mol}^{H_2O} - \alpha_{mol}^{N_2}) dr}$
3) $K = 79.43\ (R^2 = 0.63)$

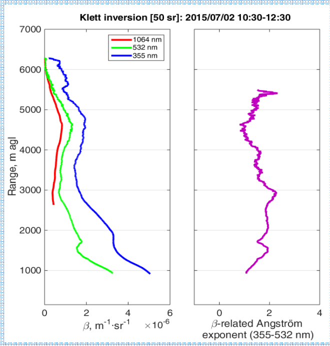
The comparison between radiosonde and lidar mixing ratio is really good pointing to a correct calibration factor.

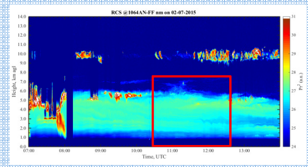
The integration time is very important: 1-hour mean allows better fits with the radiosonde whereas 2,5 hour mean a larger smooth allows measurements of 0,1 g/Kg around 8 km.



IPRAL aerosol property retrievals

Klett inversion



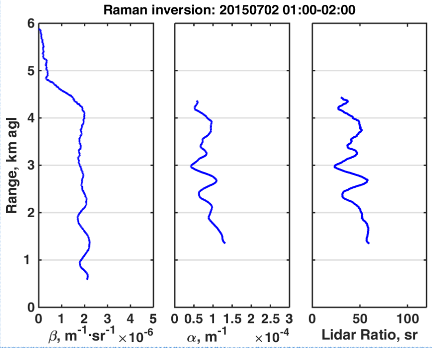


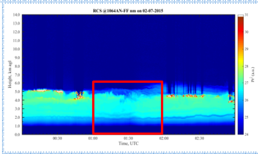
Co-located IPRAL Vs Cimel sunphotometer:
AOD(lidar)@532nm = 0,43
AOD(cimel)@500nm = 0,45
AOD(lidar)@355nm = 0,78
AOD(cimel)@340nm = 0,77

$\beta\text{-}AE_{lidar}$(355–532nm) = 1,5 ± 0,3
$\alpha\text{-}AE_{cimel}$(440–870nm)=1,3 ± 0,1

Very good agreement is obtained on Aerosol optical depth (AOD) retrieved from **IPRAL** backscatter and co-located Cimel **sun-phtometer** measurements at 532 and 355nm. In addition, $\beta\text{-}AE_{lidar}$ and $\alpha\text{-}AE_{cimel}$ agree and pointing to a fine-mode aerosol-particle predominance.

Raman inversion at 355nm





1-hour average of backscattered signals at 355 and 387nm allow extinction and backscatter profiles retrievals at 355nm, and lidar ratio.

IPRAL Raman inversions has been successfully performed during night-time, providing a lidar ratio retrieval around 45 sr at 355 nm. Evaluation of day-time performance of Raman channels is ongoing.

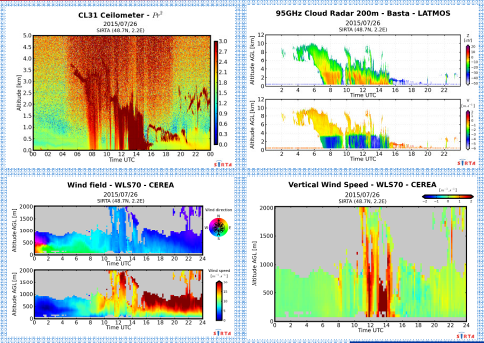
Aerosol typing

The three intensive aerosol properties derived from IPRAL's measurements allows the tropospheric aerosol typing.

$$\left.\begin{array}{c}\boldsymbol{\beta\text{–}AE(355-532nm)}\\ \boldsymbol{LR(355\ and\ 532nm)}\\ \boldsymbol{\delta(355nm)}\end{array}\right\} \Rightarrow \textbf{Tropospheric aerosol typing}$$

Ancillary measurements

Complementary capabilities of vertical-resolved measurements (e.g., **cloud radar, Doppler lidar, microwave radiometer, radiosonde, and ceilometer**) provide valuable retrievals of aerosol properties, mixing-layer development and aerosol-cloud interaction.



The development of IPRAL was realized with the support of
And the following organisms: