Preliminary testing of new approaches to retrieve aerosol properties from joint photometer-LIDAR inversion

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SHADOW campaign

(March-April, 2015 & December, 2015-January, 2016)

- Objectives
 - Saharan dust properties exploration
 - New retrieval approaches testing
 - Produce new and high quality aerosols parameters (needed for satellite validation)
- Site selection
 - Dust investigation near the source
 - Transported biomass burning and other aerosol types
 - Keep continuous and relevant aerosol study
- Collaboration/Cooperation
 - Cappa Labex
 - ACTRIS community



Fig 1. M'Bour IRD (Institut de Recherche pour le Développement)

Aerosol parameters investigated



Optical properties

- Extinction
- Absorption
- Scattering

Microphysical properties

- Vertical concentration
- Size distribution
- Complex Refractive Index (CRI)
- Particle shape

Chemical properties

Chemical speciation

Fig 2. Aerosol parameters investigated

Instrumentation

- Multi-wavelength Raman Lidar
 - 2α : Extinction coefficient at 355nm, 532nm
 - 3β: Backscattering coefficient at 355nm, 532nm, 1064nm
 - 2δ: Particle Depolarization Ratio (PDR) at 355nm, 532nm
 - LR: Lidar Ratio
 - BAE,EAE: Backscattering Angstrom Exponent and Extinction Angstrom Exponent.
 - WVMR: Water Vapor Mixing Ratio
- Sun/Lunar photometer
 - Direct sun/moon extinctions
 - Angular sky radiance & polarization measurements

PDR (δ) is defined as the ratio of the cross-polarized Lidar returned signal to the parallel polarized signal, with respect to the polarization plane of the transmitted laser beam.

$$\delta = \frac{P_{\perp}}{P_{\parallel}}$$

δ can be used as an indicator of the particle shapes: Spheres such as fogs, droplets : ~0% Molecular atmosphere: ~0.37% - 0.4 % Dust particles: ~30%-35% Cirrus clouds: ~40%-45%

LR is the ratio of aerosol extinction and backscattering coefficient

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$$LR(\lambda) = \frac{\sigma_{ext}(\lambda)}{\beta(\lambda)} = \frac{4\pi}{\omega_0(\lambda)P(\lambda,\pi)}$$

LR is independent of aerosol concentration, only depends on the aerosol property.

Instrumentation

- CIMEL Lidar—single wavelength Lidar
 - Backscattered signal at 532nm
- Doppler Lidar
 - Vertical resolved wind speed and directions
- Airborne photometer PLASMA
 - Spectral AOTs

- Particle sizing instruments GRIMM, OPC
 - Particle size distributions
- Nephelometer
 - Scattering coefficient (450, 525 and 625nm)
- Aethalometer
 - Absorption coefficient (370, 470, 520, 590, 660, 880 and 950nm)
- Other instruments
 - Particle mass concentration, chemical speciation...

Instrumentation



Fig 3. Instruments in SHADOW campaign

Case studies

Case 1: 25 January, 2016



Fig 4. Diurnal AOD and Angstrom exponent variation. (25 January, 2016)



Raman Retrieval



Fig 6. (a)Extinction and backscattering. (b) Particle depolarization and Angstrom Exponent (355/532) (25 January, 2016). Data is averaged between 14:00-16:00 UTC.

Case 2 :20 January, 2016





Fig 8. Lidar quicklook. (20 January, 2016)

Raman Retireval



Aerosol classification



GARRLiC/GRASP retrieval



Fig 12. Inputs and outputs of GARRLiC/GRASP

Extinction profile



Fig 13. Extinction retrieved from GARRLiC and comparison with Raman retrieval. (a)25 January (b) 20 January

Aerosol vertical concentration



Fig 14. Retrieved aerosol vertical concentration. (a) 25 January. (b) 20 January.

Size distribution and CRI







Fig 16. Complex refractive index(CRI). Real part (top) and imaginary part (bottom) 19

SSA profile



Absorption profile



Fig 17. Retrieved aerosol vertical absorption profile. (a) 25 January. (b) 20 January.

Conclusions and perspectives

Conclusions

- WP 3440-2 Deliverable : Technical Report on "Preliminary testing of new approaches to retrieve aerosol properties from joint photometer-LIDAR inversion "
- GARRLiC/GRASP has extended the retrieved parameter dataset by providing bimodal and vertical distributed aerosol properties. Promising results ,coincident with present understanding of aerosol properties, are obtained for the measurements from SHADOW campaign.
- Raman retrievals generally show good agreements with the reported aerosol characteristics in the previous campaigns. However, there are still some discrepancies to be further explored.

Conclusions and perspectives

Perspectives

- Retrieval products validation, more in-situ/remote sensing measurements will be analyzed and samples studied by chemical and physical laboratorial methods.
- Algorithm implementation, ground-based measurements and depolarization information maybe employed into the retrieval.
- Uncertainty study for both measurements and retrieval.
- GARRLIC/GRASP routine processing of European sites in preparation

Thanks for your attention !

Extra Slides



Fig 18. Angstrom Exponent and water vapor mixing ratio 02:00-04:00, 20 January

Retrieved Angstrom Exponent





Fig 19. Angstrom Exponent and water vapor mixing ratio 05:00-06:00, 20 January

Extinction comparison



Fig 20. Extinction comparison between PLASMA, Lidar and GRIMM. Lidar extinction computed from Klett method. (a) 355 channel. (b) 532 channel