



Aerosol profiling by combination of lidar and lunar/star-photometry

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ACTRIS-2 1st WP3 Workshop
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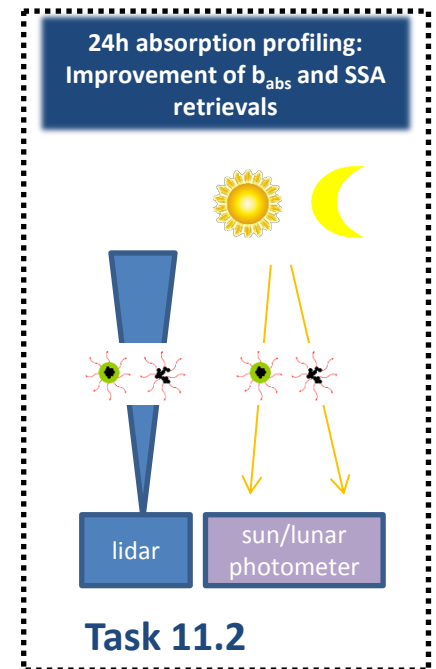
Task 11.2

24-hour absorption coefficient profiling through inversion of remote sensing observations

Objective 1: Implement the lidar stand-alone night-time retrievals using as a constraint night-time measurements from **lunar/star photometers**.

Objective 2: Adapt the GRASP algorithm for the night-time retrievals of the aerosol absorption coefficient and SSA profiles, combining the AODs from the lunar/star photometers with the lidar elastic measurements.

Objective 3: Test advanced night-time inversions utilizing the lunar/star photometer synergy with multiwavelength Raman lidars at selected ACTRIS sites.



Aerosol profiling by combination of lidar and lunar/star-photometry

Objective 1: Implement the lidar stand-alone night-time retrievals using as a constraint night-time measurements from **lunar/star photometers**.

- U Hertfordshire is working on the Lidar stand-alone night-time retrievals.
- Using three study cases including Raman lidar profiles and sun/star photometer provided by U Granada, tests of the effect of using as a constraint AOD night-time measurements are going on.
- The use of night-time AOD from photometry will be used for testing alternatives to so-called 3+2 approach (named after the 3+2 available wavelengths for backscatter and extinction) reducing the number of lidar channels (i.e., 2+1 or 1+1, 3+0) .

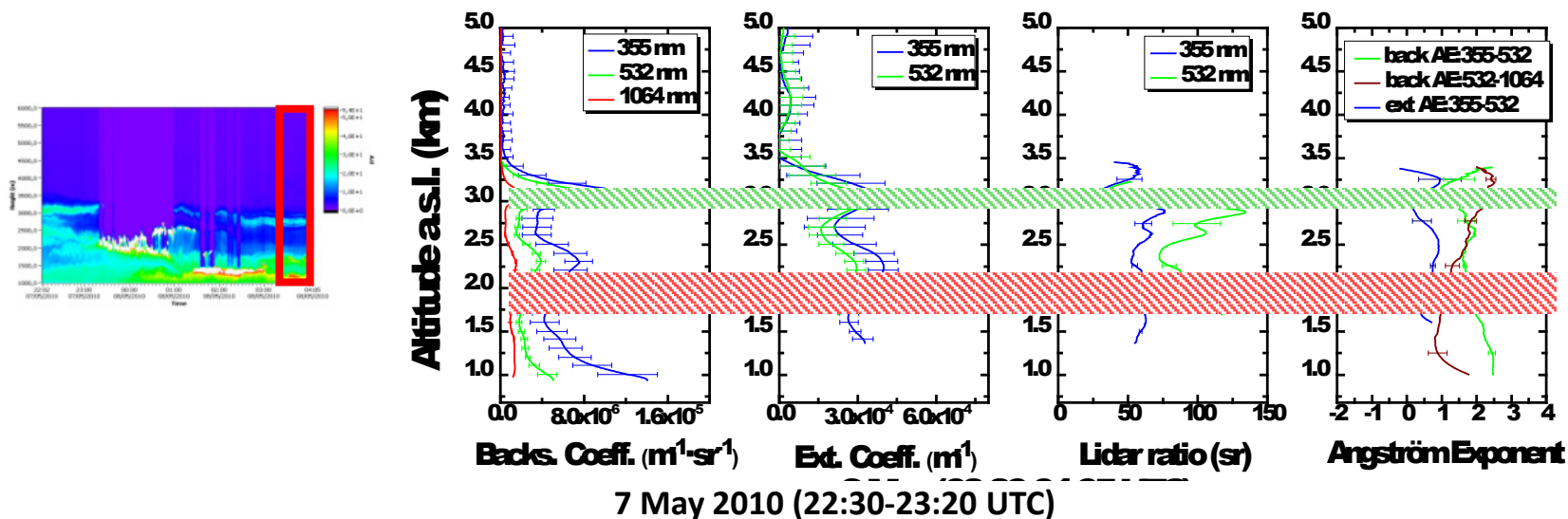


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Objective 1: Implement the lidar stand-alone night-time retrievals using as a constraint night-time measurements from **lunar/star photometers**.

- Eyjafjallajökull volcanic plume case detected over Granada processed using lidar stand-alone night-time retrievals. (Navas-Guzman et al, 2013 JGR)

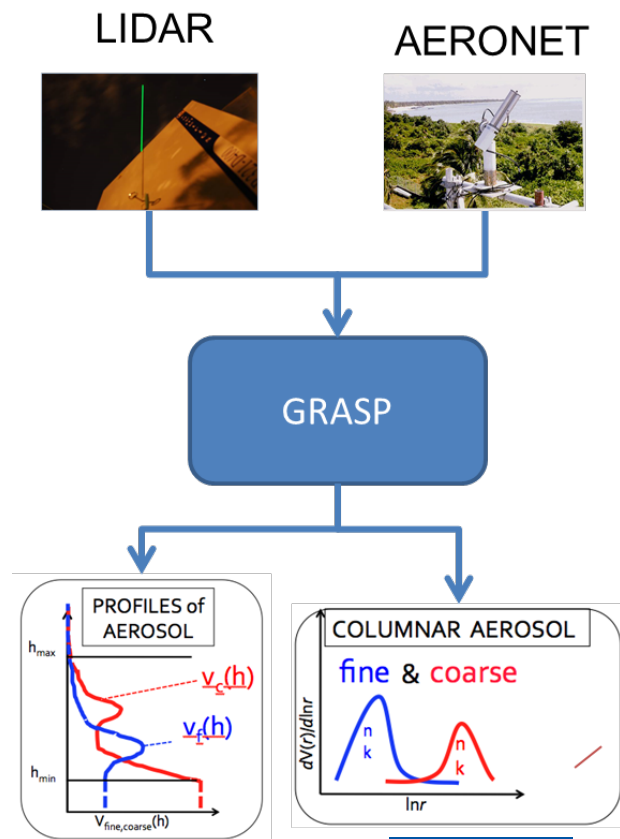


| | Time (UTC) | Range (km) | r_{eff} (μm) | β -AE 355/532 | LR_{355} (sr) | δ_p (532 nm) |
|-------------|-------------|------------|------------------------------------|---------------------|------------------------|---------------------|
| PBL | 22:30-23:20 | 2.0-2.5 | 0.30±0.11 | 1.7±0.1 | 55±2 | 4% |
| Volc. Plume | 22:30-23:20 | 2.9-3.1 | 0.32±0.14 | 1.1±0.2 | 48±14 | 6% |

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Objective 2: Adapt the GRASP algorithm for the night-time retrievals of the aerosol absorption coefficient and SSA profiles, combining the AODs from the lunar/star photometers with the lidar elastic measurements.

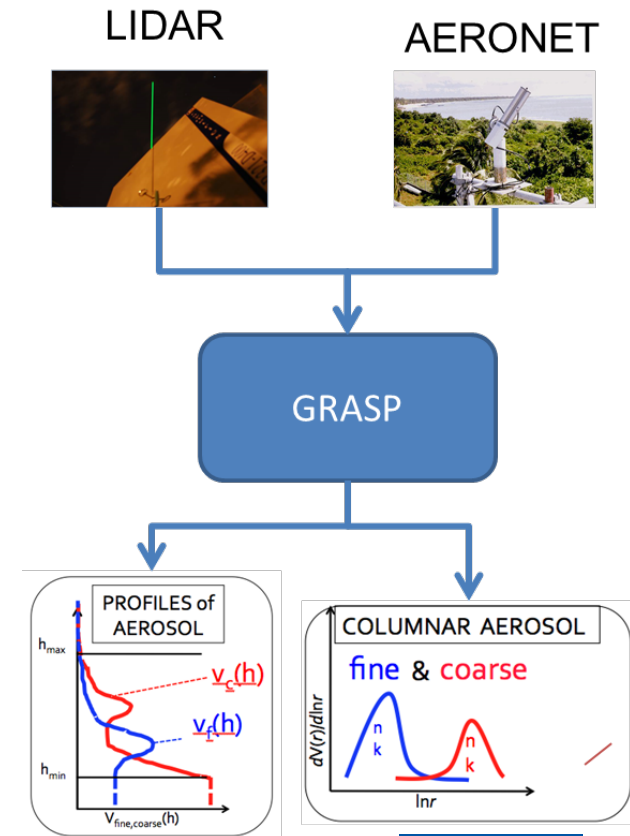
- LOA is working on adapting GRASP (Generalized Retrieval of Aerosol and Surface Properties) for the retrieval of profiles of aerosol microphysical properties combining AOD night-time measurements and elastic lidar profiles.
- Experience gained with GARRLIC (Generalized Aerosol Retrieval from Radiometer and Lidar Combined data) using day-time measurements is crucial (Alexandra Tsekeri talk).
- In short study cases provided by U Granada will be used for testing GRASP night-time retrievals.



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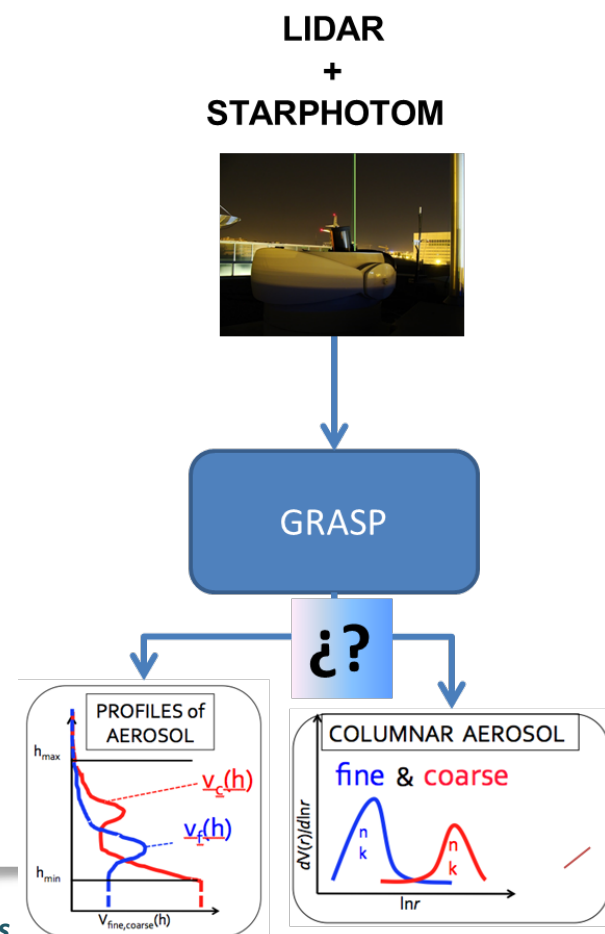
- Day-time approach combine LIDAR and SUN Radiometer data (both AOD and Sky radiance).



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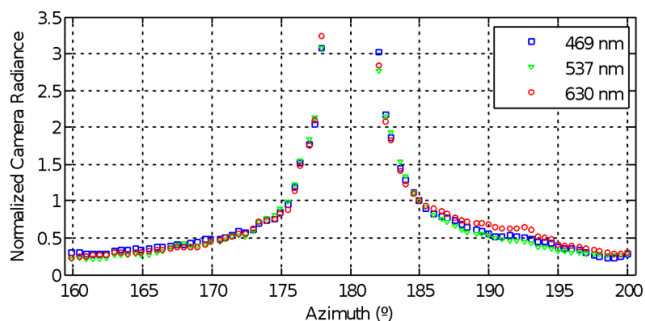
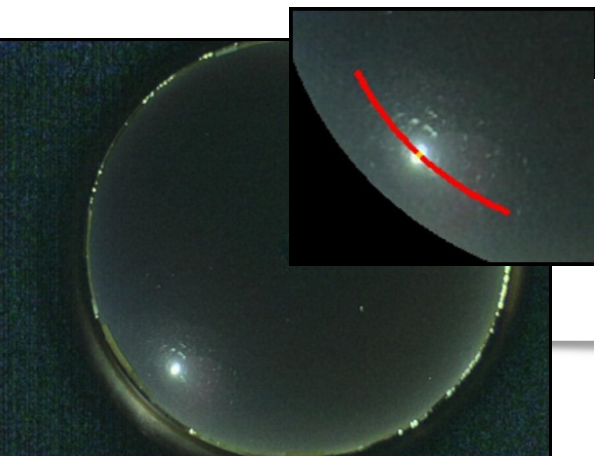
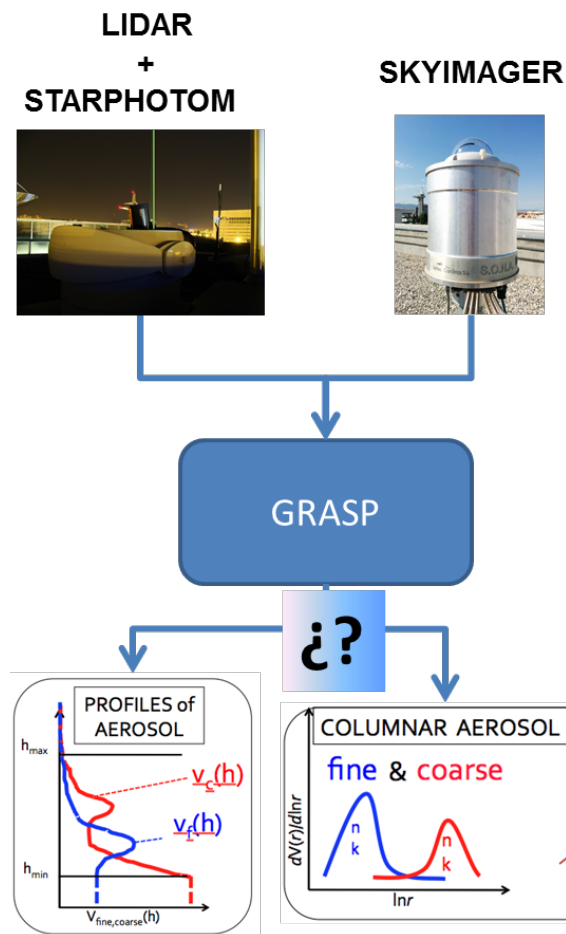
- Day-time approach combine LIDAR and SUN Radiometer data (including both AOD and Sky radiance).
- Night-time information from LUNAR/STAR photometry only provides AOD.



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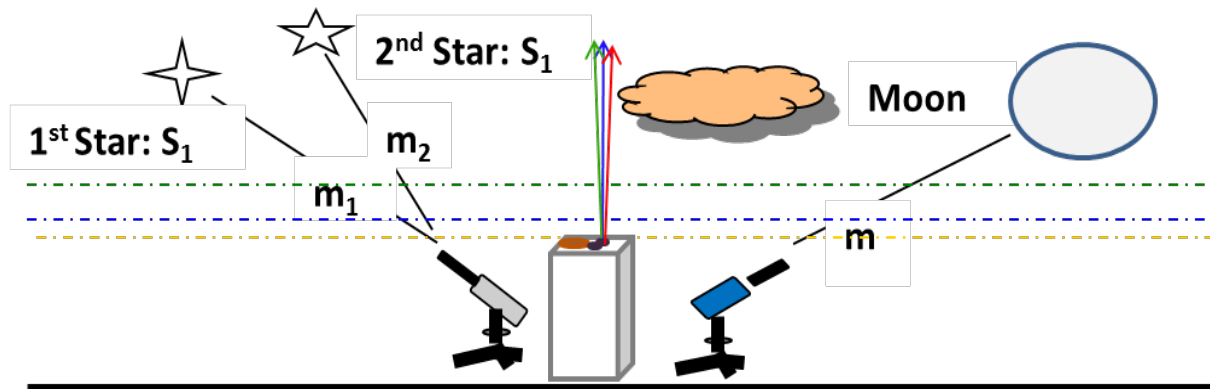
- Day-time approach combine LIDAR and SUN Radiometer data (both AOD and Sky radiance).
- Night-time information from LUNAR/STAR photometry only provides AOD.
- Alternatives exploring the use of Sky-imagers for the retrieval of lunar aureole could improve GRASP input. (Román et al., 2015).



Aerosol profiling by combination of lidar and lunar/star-photometry

Objective 3: Test advanced night-time inversions utilizing the lunar/star photometer synergy with multiwavelength Raman lidars at selected ACTRIS sites.

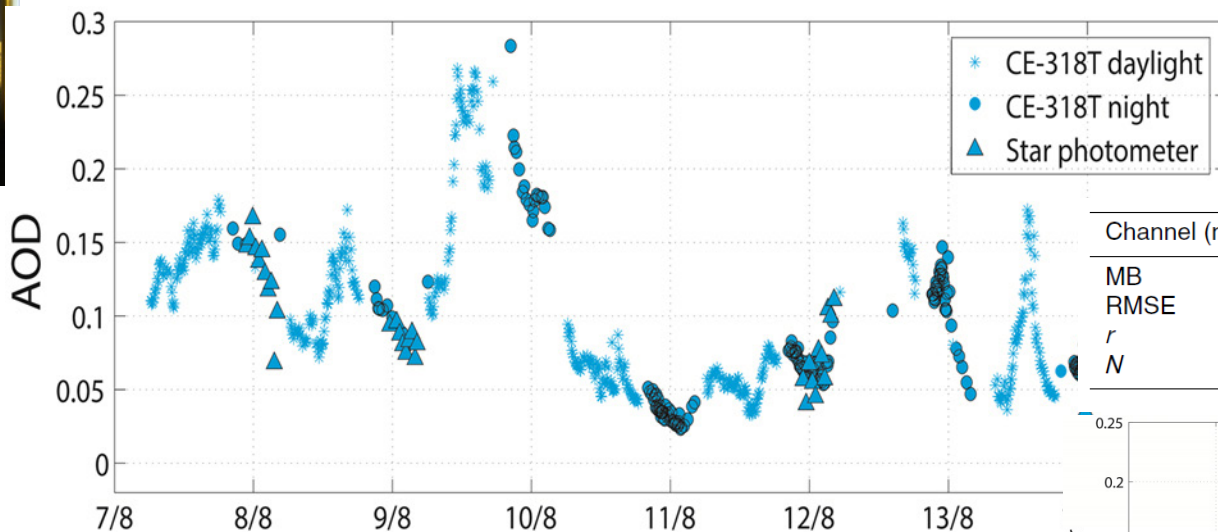
- Different methodologies, applied for lunar and star photometry, will be tested for accurately determining the night-time AOD through **system intercomparisons in Potenza (CNR) and Granada (UGR)**.



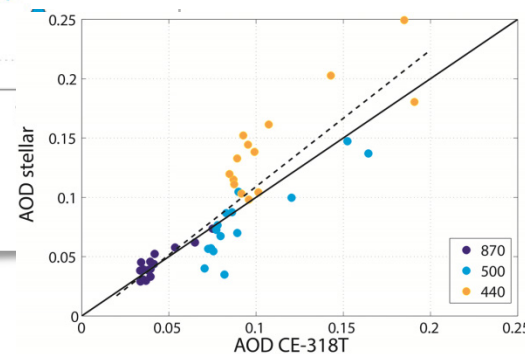
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Objective 3: Test advanced night-time inversions utilizing the lunar/star photometer synergy with multiwavelength Raman lidars at selected ACTRIS sites.

- Testing lunar and star photometry for accurately determining the night-time AOD. (Barreto et al, Atmos. Meas. Tech. Discuss., 8, 11077–11138, 2015)



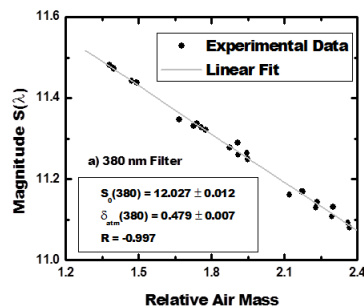
| Channel (nm) | 870 | 500 | 440 |
|--------------|--------|-------|--------|
| MB | -0.001 | 0.013 | -0.033 |
| RMSE | 0.003 | 0.009 | 0.018 |
| r | 0.946 | 0.937 | 0.911 |
| N | 15 | 15 | 14 |



Aerosol profiling by combination of lidar and lunar/star-photometry

Objective 3: Test advanced night-time inversions utilizing the lunar/star photometer synergy with multiwavelength Raman lidars at selected ACTRIS sites.

- The advanced night-time inversions will be, initially, applied utilizing the lunar/star photometer synergy with multiwavelength Raman lidars at the ACTRIS sites in Potenza (CNR) and Granada (UGR).
- New measurements combining lidar profiling and lunar/star photometer measurements will be collected along the next months.
- Star photometer under calibration in Calar Alto Astronomical Observatory.



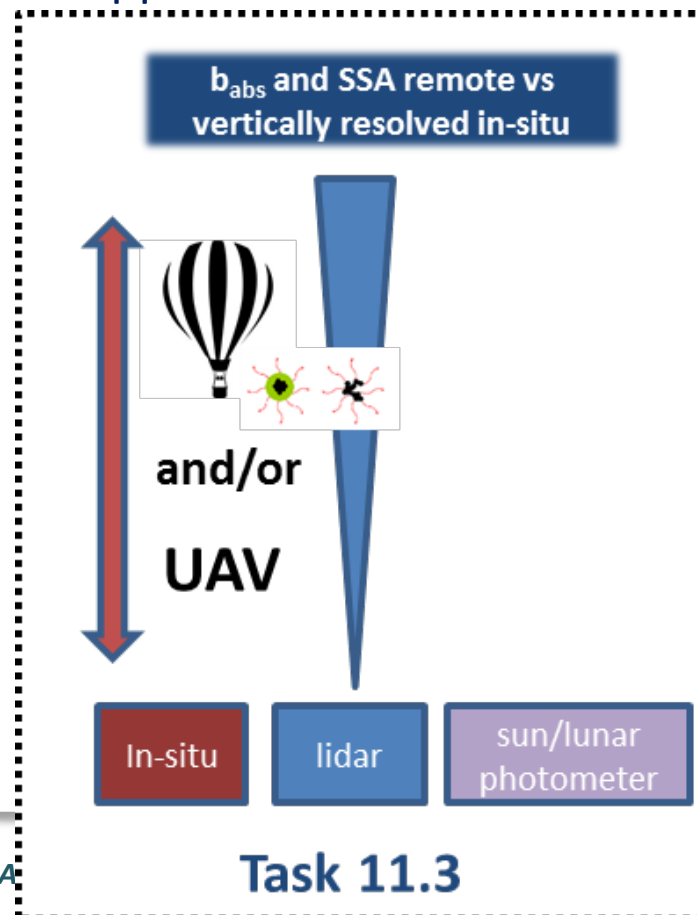
| Filter | $S_0(\lambda)$ | $\delta_{\text{atm}}(\lambda)$ | R |
|--------|--------------------|--------------------------------|--------|
| 380 | 12.027 ± 0.012 | 0.479 ± 0.007 | -0.997 |
| 436 | 14.310 ± 0.019 | 0.233 ± 0.009 | -0.978 |
| 670 | 14.196 ± 0.024 | 0.049 ± 0.012 | -0.653 |
| 880 | 13.558 ± 0.015 | 0.04 ± 0.01 | -0.632 |
| 1020 | 10.288 ± 0.007 | 0.012 ± 0.003 | -0.599 |



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Objective 3: Test advanced night-time inversions utilizing the lunar/star photometer synergy with multiwavelength Raman lidars at selected ACTRIS sites.

- The methodology will be applied in the validation campaigns of Task 11.3.



DELIVERABLES

- **D11.2: *Optimized inversion algorithms*** for the determination of absorption coefficient and SSA vertical profiles suited for day and night operation, (to be tested in Task 11.3) **(M24, UGR)**



MILESTONES

-  **MS11.3: *First inversion algorithms*** for the determination of absorption coefficient and SSA vertical profiles **available (M12, UGR)**



Thanks !!



Task 11.2 – Main challenges, approach, expected output

- **Main challenges and proposed approach:**

1. Inversion procedures require models linking the optical properties of the atmospheric aerosol with microphysical properties. These models depend on the shape of real particles. To consider the non-spherical geometry of real particles, state of the art treatment of particles as spheroids will be used.
2. In lunar photometry it is necessary to use a lunar irradiance model to estimate Moon's extraterrestrial irradiance. RObotic Lunar Observatory (ROLO) Project will be used for this purpose.
3. Star-photometers present some challenges associated to the calibration process due to the use of different stars along the night, that can change with season. Calibration in high mountain places with frequent on-site calibration checking will be implemented.

Task 11.2 – Main challenges, approach, expected output

- **Main challenges and proposed approach (continue):**

4. Heterogeneity issues represent a challenge considering that most lidar systems point close to the zenith, while photometers track the moon or a certain stars in the sky dome. The availability of scanning lidars at the core observational sites will be used to evaluate this effect.

- **Expected output:**

Retrieval algorithm for aerosol absorption coefficient and SSA profiling based on the combination of multiwavelength elastic lidar and sun photometers (daytime) and lunar/star photometers (night time), including different sets of input variables

Task 11.2 – Main risks and solutions

1. Modelling issues require the synergetic combination of lidar measurements and lunar/star photometer measurements. These represent a risk due to the instruments' peculiarities. To reduce this risk the experience gained in the synergetic use of lidar and sun-photometer measurements will be useful.
2. Test of the inversion procedures will be based on the availability of good databases to be gathered at Potenza and Granada. Risk associated to the use of experimental set ups is always present. Nevertheless, the use of two sites and the planned continuous operation of the instrumentation guaranties the availability of good data sets. Furthermore, the experimental campaigns planned in task 11.3 will contribute with additional data for the evaluation of the inversion procedures.