



ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

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EVID41: Assessment of EarthCare Aerosol and Cloud Products through Ground-Based Measurements from the E-PROFILE and AERONET Networks

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AEROCLOUD project



- **EVID41:** Assessment of EarthCare Aerosol and Cloud Products through Ground-Based Measurements from the E-PROFILE and AERONET Networks (AEROCLOUD)
- **PI:** Francisco Navas Guzmán
- **Financial Entity:** Junta de Andalucía (Regional Government) **Period:** 01.01.2023 – 31.12.2026

GENERAL OBJECTIVE

Advancement in the **4D continental monitoring of atmospheric aerosol** properties using the **synergy** of ground-based and satellite **remote sensing** instruments

- **SO#1.** Improvement in aerosol characterization by means of passive and active remote sensing
- **SO#2.** Development of network for 4D characterization of atmospheric aerosol by combination of sun/sky photometers and ceilometers
- **SO#3.** 4D continental characterization of the atmospheric aerosol during medium-long range transport
- **SO#4.** Evaluation of the capability of synergy of ground-based and satellite observations for a global monitoring of aerosol optical and microphysical properties
- **SO#5.** Validate and add new aerosol products to the EarthCARE satellite mission

AEROCLOUD team



University of Granada, Spain

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- Dr. Alberto Cazorla Cabrera
- Dr. Daniel Pérez Ramírez
- Dr. Ana del Águila
- MSc. Jorge Muñiz
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University of Valladolid, Spain

- Prof. Carlos Toledano
- Dr. Roberto Román

MeteoSwiss, Switzerland

- Dr. Alexander Haefele (MeteoSwiss)
- Dr. Rolf Rüfenacht (MeteoSwiss)
- Dr. Giovanni Martucci

The Cyprus Institute, Cyprus

- Dr. Franco Marengo



UGR | Universidad
de Granada



Universidad de Valladolid



THE CYPRUS
INSTITUTE
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The E-PROFILE ALC network

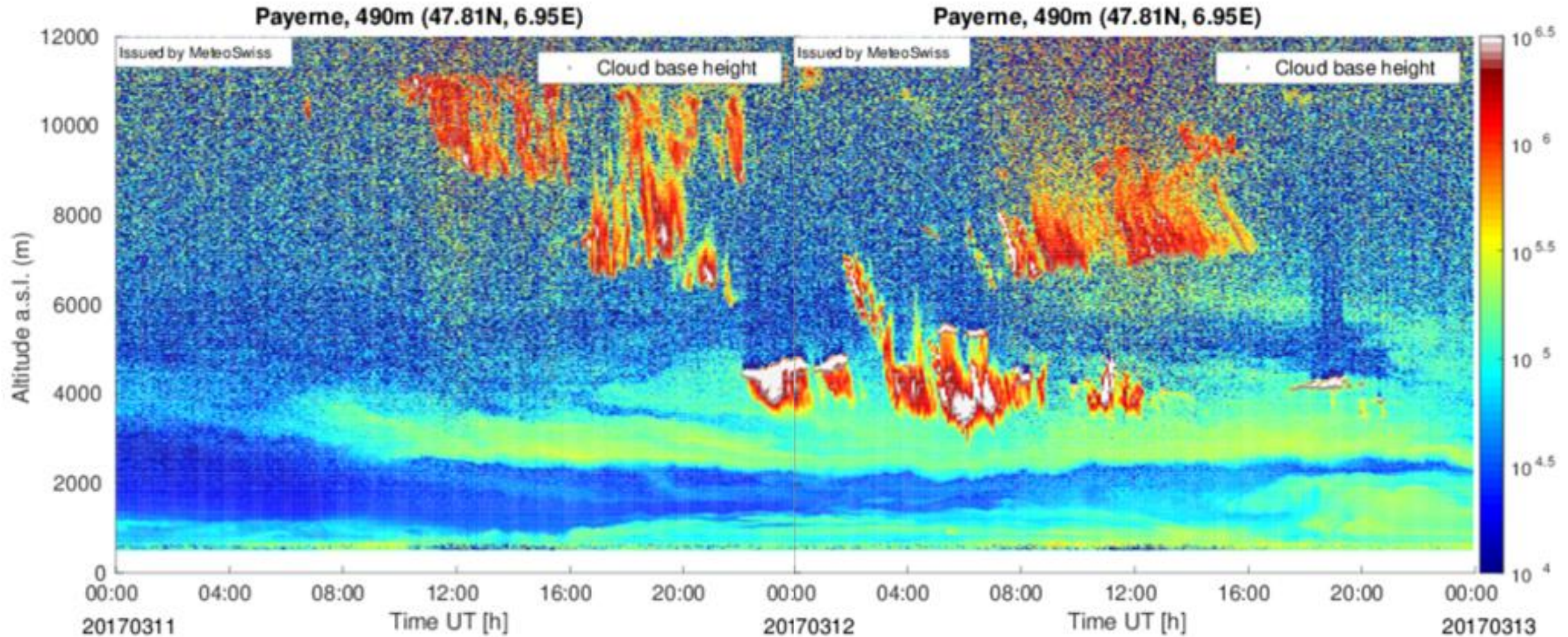


Assess vertical /horizontal aerosol distribution and transport in real-time

- commercial ALCs (different types)
- more than 400 instruments from 22 European countries (still growing)
- in operation 24/7
- central data processing
- automatic calibration
 - Rayleigh calibration (used here)
 - Cloud calibration for lower power
- real-time data + quicklook delivery

<https://e-profile.eu/>

The E-PROFILE ALC network



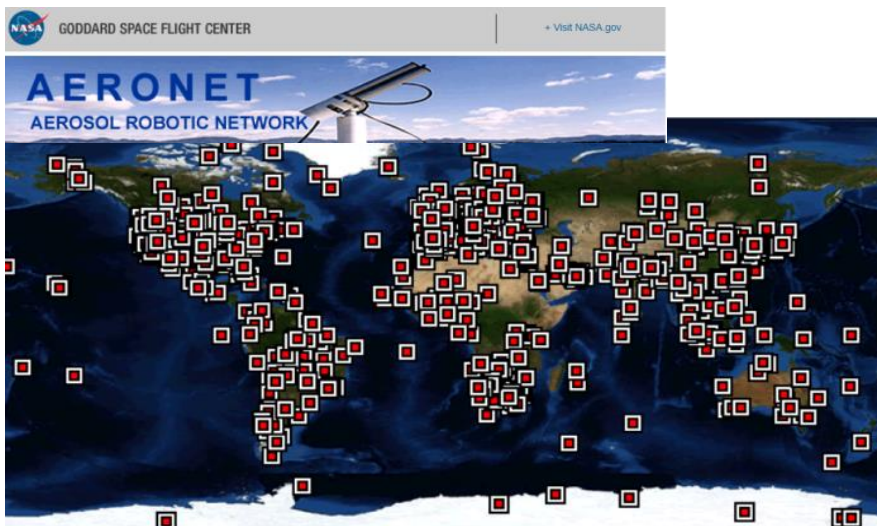
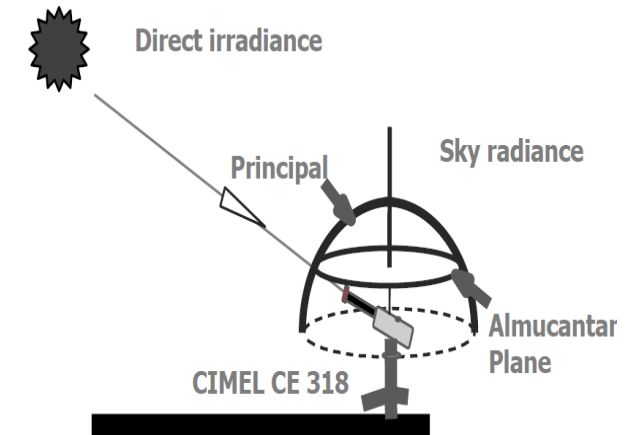
Passive Remote Sensing Instruments



➤ Sun/sky/lunar photometer (CIMEL Electronique)



- Filters: 340, 380, 440, 500, 675, 870, 940, 1020 and 1640 nm
- Robotic system:
 - Solar direct irradiance
 - Sky radiance
 - Lunar direct irradiance

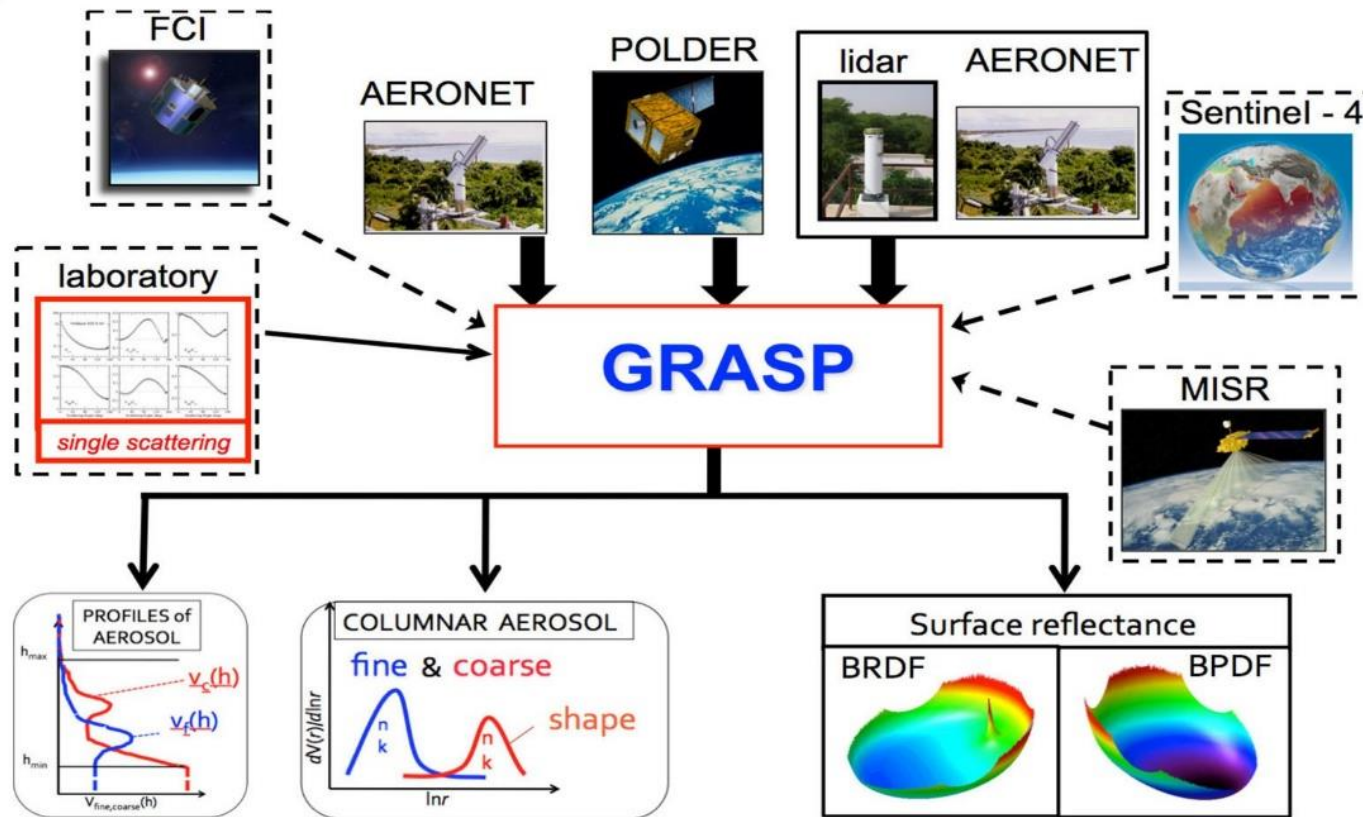


AERONET: dense global-scale network of **column-integrated** aerosol measurements (long dataset: more than 25 years)

- Aerosol optical depth (AOD)
- Angström exponent (AE)
- Particle size distribution (PSD)
- Refractive index (RI)
- Single-scattering albedo (SSA)



GRASP (Generalized Retrieval of Aerosol and Surface Properties)



[Dubovik et al., 2014]

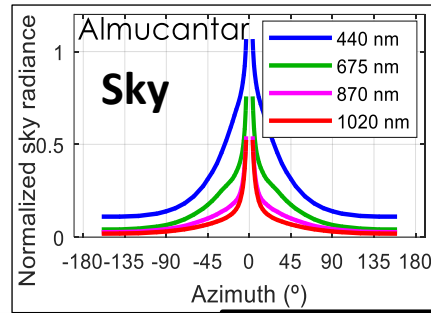
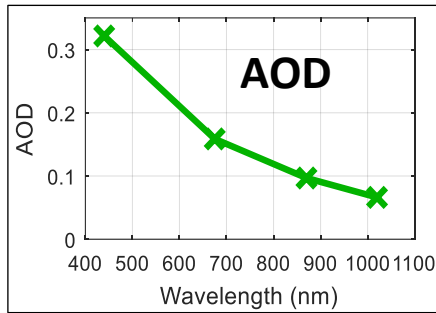
- Developed in the Laboratoire d'Optique Atmosphérique at University of Lille(France)
- GRASP is a versatile and open-source algorithm (www.grasp-open.com) [Dubovik et al., 2014]
- Can retrieve columnar and vertical properties of atmospheric aerosols from a variety of remote sensing observations

GRASP_{pac} scheme



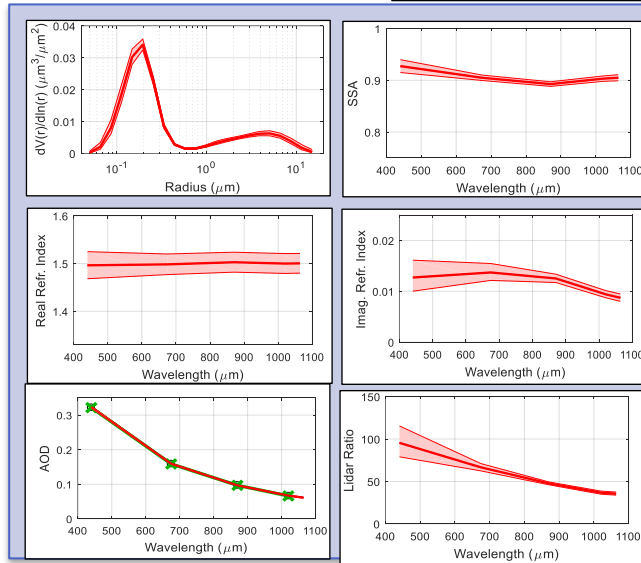
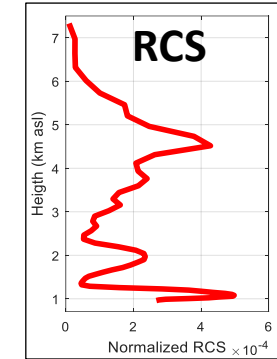
Cimel CE318

- Aerosol Optical Depth (AOD) and sky radiances at 440, 675, 870 and 1020 nm
- **AERONET** data



Lufft CHF15k

- Range corrected signal (RCS) at 1064 nm
- Resolution 15 m



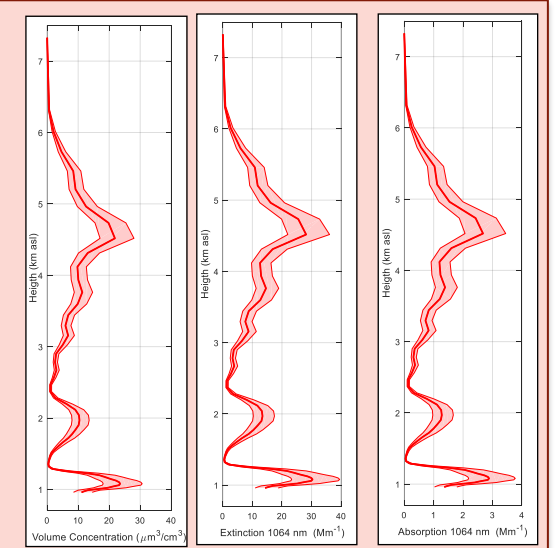
Column-integrated

GRASP_{pac}
(ceilo&SPM,
Román et al. 2018)

- Size distribution (SD)
- SSA
- Refr. Indices
- Lidar ratio
- ...

Vertical

- Volume Concentration
- Extinction
- Backscatter
- Absorption
- Scattering
- ...



Methodology and Work Plan



Work Package

WP-1: Gathering E-PROFILE data (L0-10M → L0+26M)

WP-2: Gathering simultaneous and co-located ceilometer and sun/sky measurements from E-PROFILE/AERONET networks (L0-10M → L0+26M)

WP-3: Implementation of automatic routines to retrieve aerosol optical and microphysical properties using GRASP (L0-10M → L0+14M)

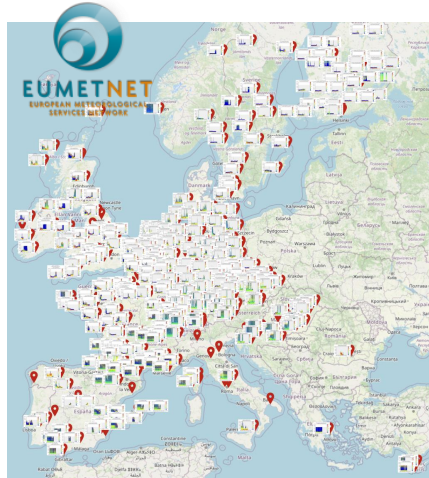
WP-4: Synergy AERONET with ATLID observations for aerosol retrievals (L0-4M → L0+26M)

WP-5: Validation of EarthCARE products using E-PROFILE network (Phase E2 → L0+24M)

WP-06: Validation of EarthCARE/AERONET retrievals with ground-based methodologies (Phase E2 → L0 + 24M)

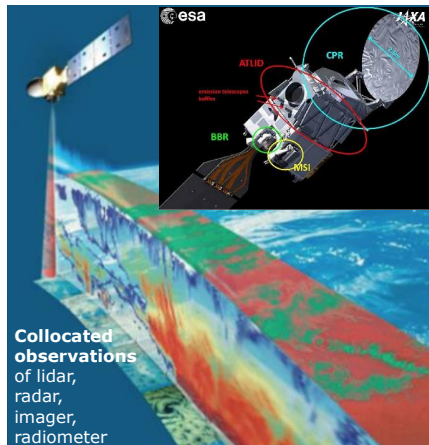
WP-07: Communication and dissemination (L0 → L0 + 36M)

E-PROFILE and EarthCARE

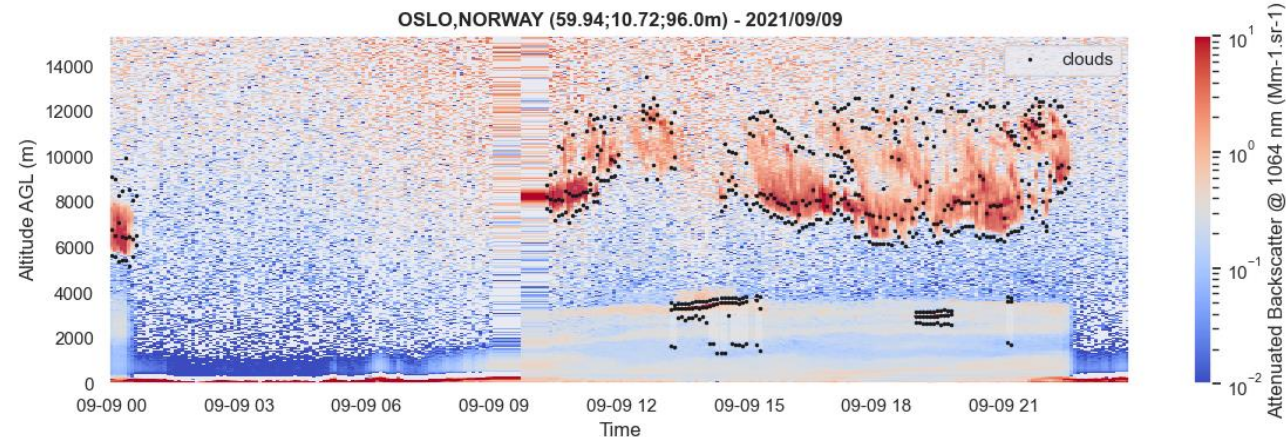


Validation of EarthCARE products using E-PROFILE network

- Coincidence criteria between ceilometers and ATLID will be based on 3 hours and 120 km distance to the overpass
- AEROCLOUD will target only λ - independent products:
 - *Feature masks (clear sky, cloudy sky, aerosol layer, etc.)*
 - *cloud height, cloud phase,*
 - *aerosol layer boundaries ...*
- L2 product assessment will be carried out using longer-term observations



Coincidence criteria: 3 hours and 120 km distance to the overpass

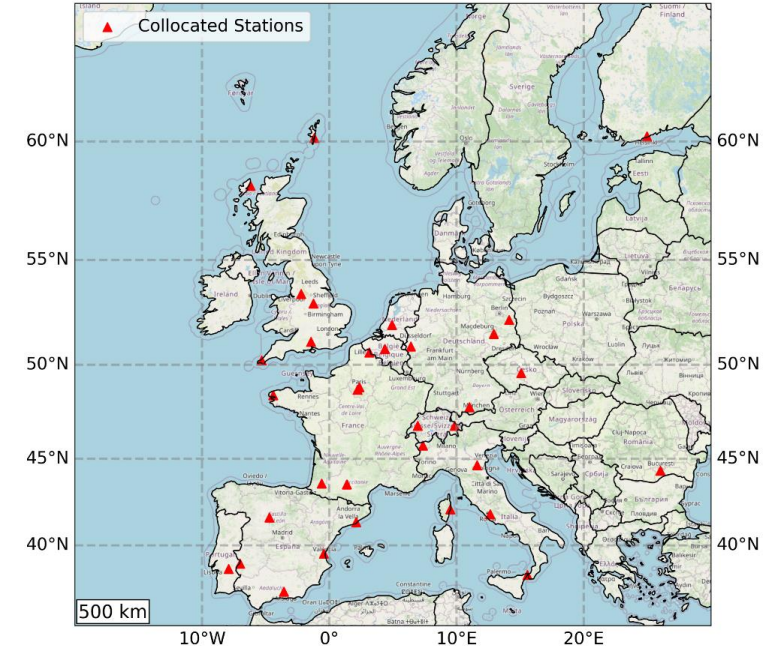


E-PROFILE and AERONET



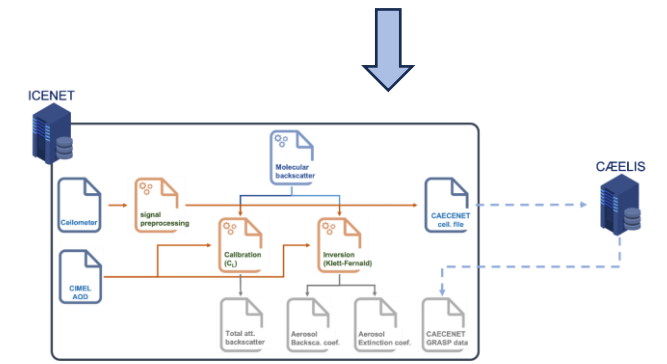
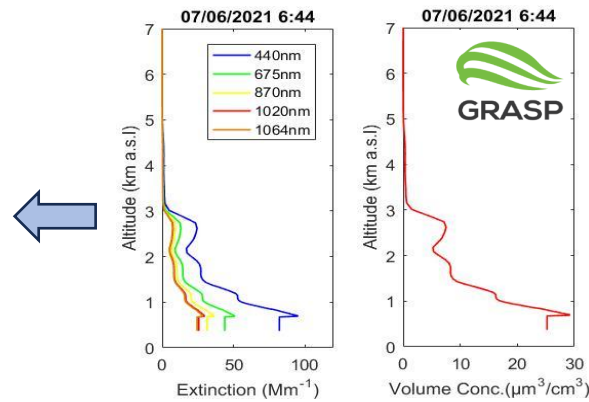
Validation of EarthCARE products using the synergy of SPM and ceilometers

- Gathering simultaneous and co-located ceilometer and sun/sky measurements from E-PROFILE/AERONET networks
- Data from more than **44 co-located E-PROFILE and AERONET stations**
- Creating an automatic alerting system adapted to EarthCARE overpasses by selecting the closest pixels near simultaneously to the E-PROFILE and AERONET stations over Europe
- Implementation of automatic routines to retrieve aerosol optical and microphysical properties using GRASP
- Vertical profiles of optical and microphysical properties distributed across Europe

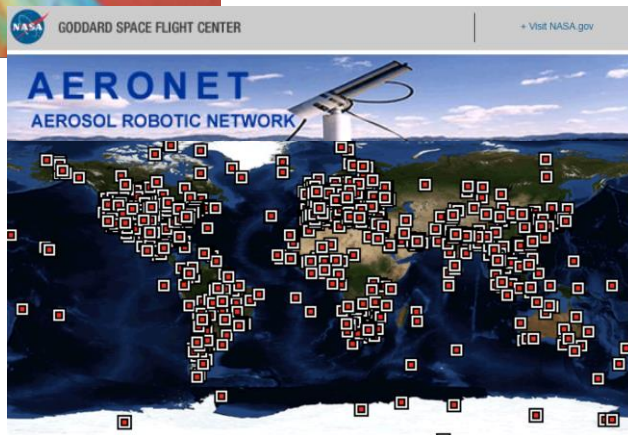
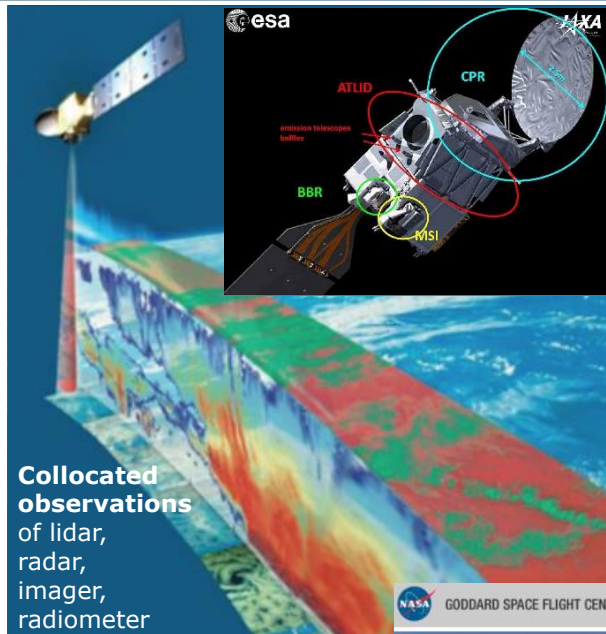


Column-integrated properties: Aerosol Optical Depths at different wavelengths, single-scattering albedo (SSA), lidar ratio (LR), and effective

Vertical profiles of backscatter, scattering, extinction, and absorption coefficients at 440, 675, 870, 1020, and 1064 nm



EarthCARE and AERONET



ATLID and AERONET measurements

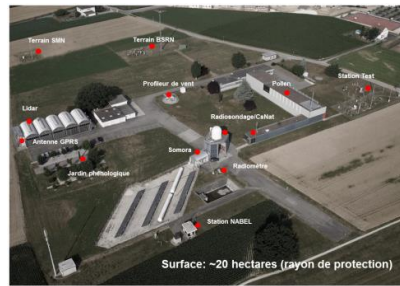
- Synergy of column-integrated aerosol measurements from AERONET with ATLID observations for aerosol retrievals
- New products to EarthCARE (optical and microphysical properties from GRASP algorithm)
- Validation versus E-PROFILE/AERONET synergy
 - Evaluation of backscatter and extinction coefficients
 - Evaluation of microphysical properties from both approaches (effect of wavelength dependency)
 - Issues of the geometry of the measurements

Aerosol vertical information on a global scale

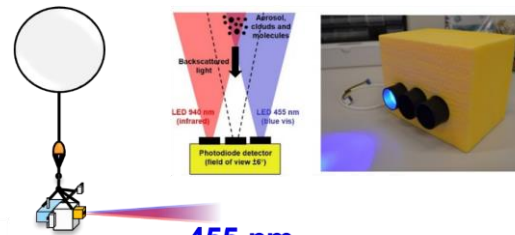
Experimental Field Campaigns



➤ Field campaigns in winter and summer 2025



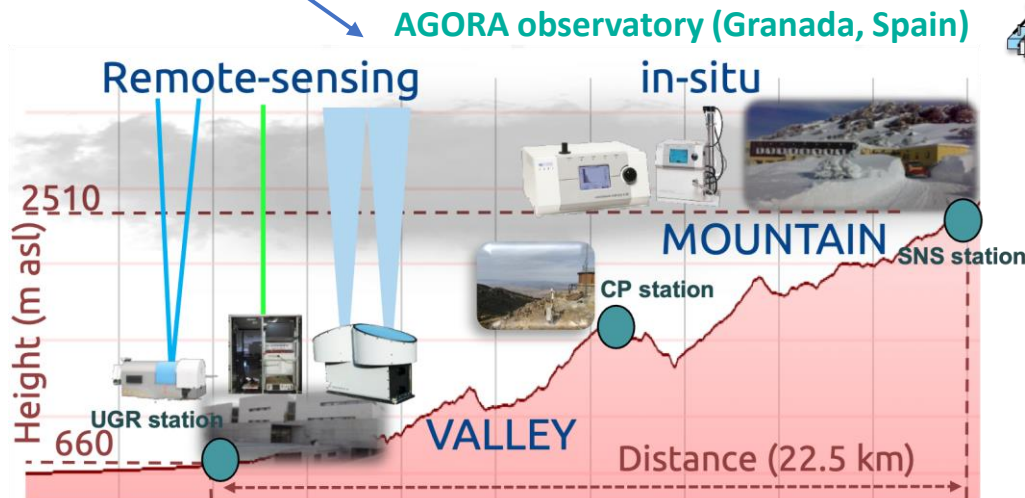
Payerne station (Switzerland)



**455 nm
940 nm
Cobalt sondes**



Drone measurements



AGORA observatory (Granada, Spain)

State-of-the-art active and passive remote sensing and in-situ techniques

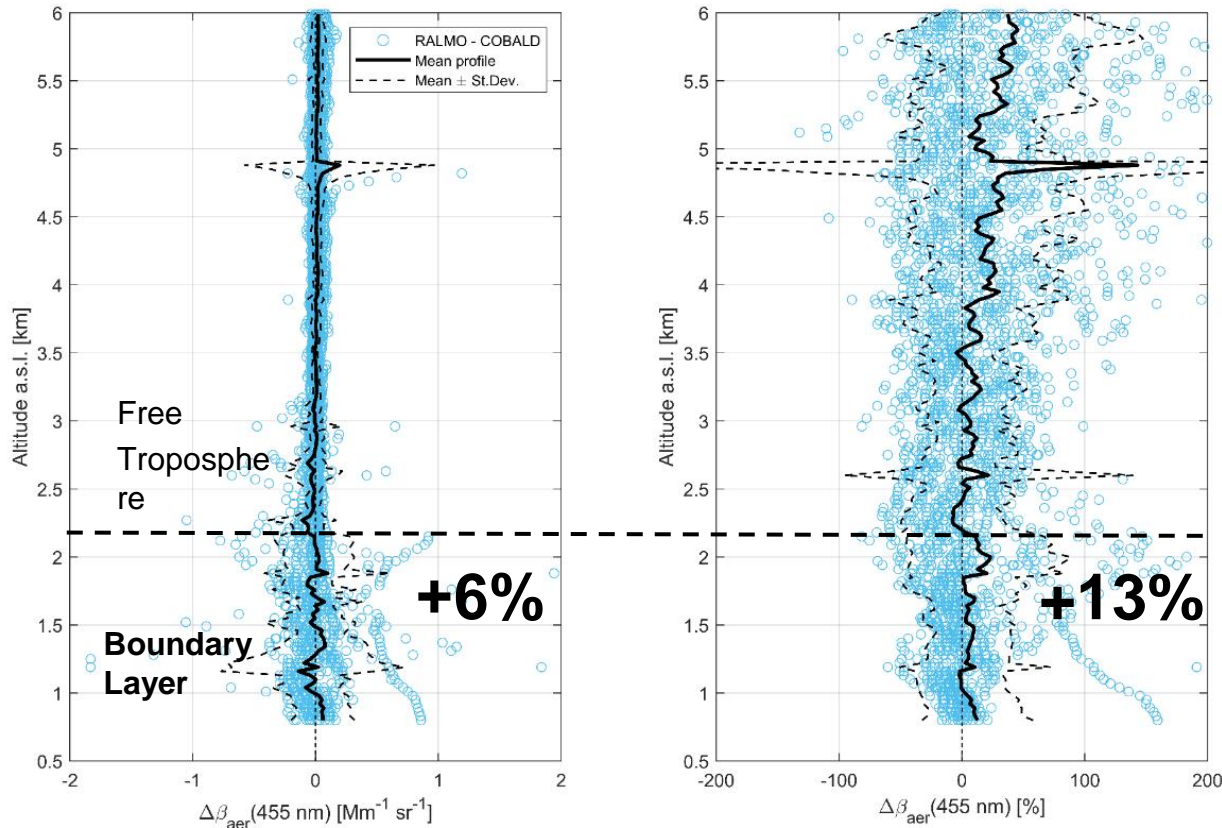
- Multi-wavelength Raman lidar
- Microwave radiometer (HATPRO)
- Ceilometer (Lufft, CHM15K)
- Cloud radar (94 GHz, RPG)
- Integrating nephelometer (TSI Model 3563)
- Doppler lidars
- Drones measurements
- Cobalt sondes
- Weather stations

Evaluation of EarthCARE products and the different approaches

- Validation of E-PROFILE/AERONET synergy
- Validation of EarthCARE/AERONET synergy
- Evaluation of backscatter and extinction coefficients
- Evaluation of microphysical properties from both approaches (effect of wavelength dependency)
- Issues of the geometry of the measurements

Validation of lidar profiles

Total 17 profiles (2016-2019), RH < 90%



- RALMO and CHM15K successfully reproduce the vertical structure of boundary layer aerosol observed by COBALD, including fine structures
- Mean \pm standard deviation discrepancies for 0-2 km altitude:
 - $\Delta\beta_{\text{aer-455nm}}^{\text{Ralmo-Cobald}} = +6\% \pm 40\%$
 - $\Delta\beta_{\text{aer-940nm}}^{\text{Ceilo-Cobald}} = +13\% \pm 51\%$
- Large standard deviations mostly due to atmospheric variability (balloon spatial drift with altitude, time integration)

Brunamonti, S., Martucci, G., Romanens, G., Poltera, Y., Wienhold, F. G., Hervo, M., Haeefe, A., and Navas-Guzmán, F.: Validation of aerosol backscatter profiles from Raman lidar and ceilometer using balloon-borne measurements, *Atmos. Chem. Phys.*, 21, 2267–2285, 2021.

EarthCARE validated products



Sensor/product	Validation
ATLID	A-FM: validate the detection of aerosol/cloud layers or clear sky identification
	A-AER: extinction, backscatter, depolarization, aerosol layer, aerosol type at 355 nm.
	A-EBD
	A-TC (target classification)
	A-ALD: aerosol layer descriptors Will be validated with the ceilometers.
Multi-Spectral Imager (MSI)	M-CM the cloud flag will be validated
	M-AOT at 670 nm from GRASP
	C-TC: cloud layer base will be validated with the ceilometers
Synergetic products	ATLID + CPR: The target classification (AC-TC) ATLID + CPR + MSI: the cloud and aerosol properties (ACM-CAP), particularly the aerosol number concentration and extinction, the composite product (ACM-COM) for the aerosol optical depth at 355 nm and aerosol type and finally the radiances (ACM-RT) for the 1D direct and diffuse surface irradiance.



- The **Ceilometer network E-profile** offers continuous observations of aerosols and clouds on a European scale, making it a **valuable resource for validating certain EarthCARE** products
- The synergy between **co-located ceilometer and sun-photometer instruments and the use of GRASP** algorithm enhances the mission by providing additional optical and microphysical information for validation purposes
- Leveraging the synergy between **Aeronet data and EarthCARE introduces new products** to the mission and enables exploration of factors such as wavelength dependency and measurement geometry
- Several **field campaigns** will be conducted in Southwest and Central Europe to **validate EarthCARE** and the **different approaches** proposed in this project

A satellite image of the Mediterranean Sea region, showing the sea, surrounding landmasses, and cloud patterns. The sea is a deep blue, and the land is green and brown. Clouds are white and wispy, with some darker areas indicating shadows or thicker clouds.

Thank you very much for your attention!!

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Junta de Andalucía
Consejería de Universidad,
Investigación e Innovación

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