



# ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

Unmanned Aerial Vehicles and other observations  
for the cal/val of EarthCARE

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*<sup>1</sup>The Cyprus Institute, Aglantzia, Nicosia, Cyprus*

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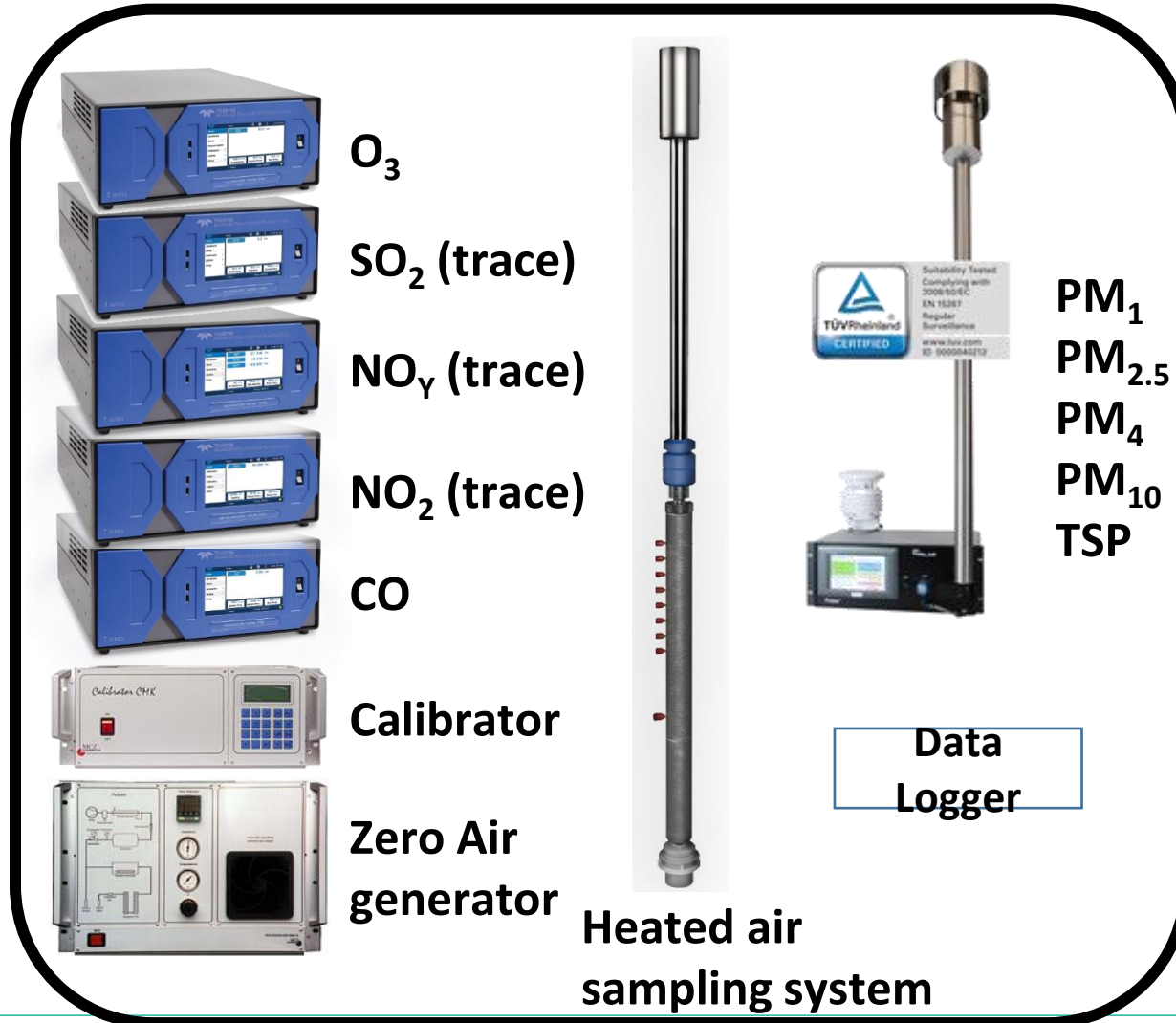
## (CARE-C)

- Cyprus Atmospheric Observatory (CAO)
- Unmanned Systems Research Laboratory (USRL)
- Environmental Predictions Department (EPD)
- A combination of research, education, and innovation activities: investing in excellence and transfer of technology and knowledge
- Greenhouse gases, the water cycle, extreme weather, atmospheric dust, air pollution, and their impacts
- EMME-CARE project: scientific, technological and policy solutions for environmental challenges
- Eastern Mediterranean and Middle East region (EMME)





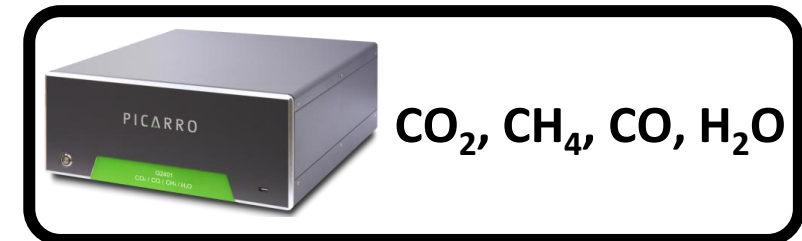
## Air quality Instrumentation **x2** for CAO **Troodos** and **AMX**



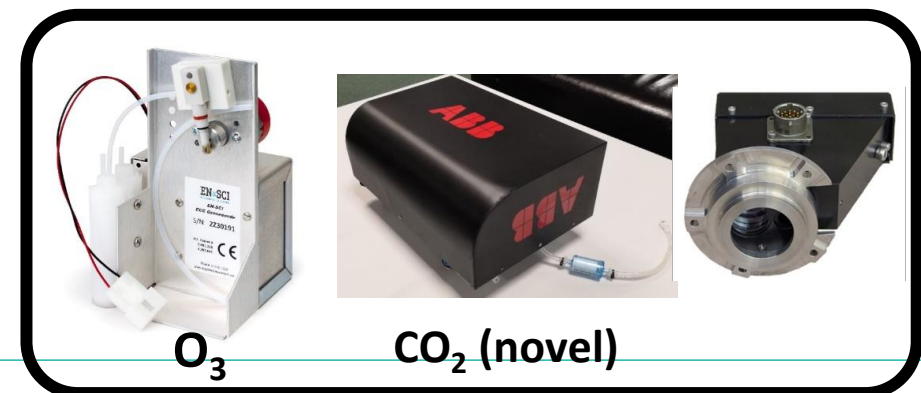
A collection of air quality instruments including gas analyzers, a heated air sampling system, a data logger, a calibrator, and a zero air generator.

- $O_3$
- $SO_2$  (trace)
- $NO_y$  (trace)
- $NO_2$  (trace)
- CO
- Calibrator
- Zero Air generator
- Heated air sampling system
- Data Logger
- $PM_{10}$
- TSP
- $PM_{10}$
- $PM_4$
- $PM_{2.5}$
- $PM_1$

## Calibrator and data logger for CAO **Cyl**



## Instruments for **UAV**



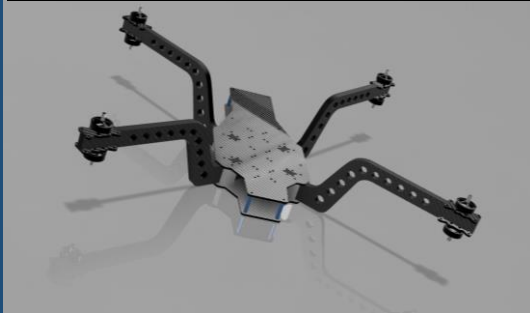


- A network of ground-based instruments at three **Cyprus Atmospheric Observatory** stations :  
*sunphotometers, ceilometers, 1 lidar and 1 flux station.*



(USRL)

**Design**



Design

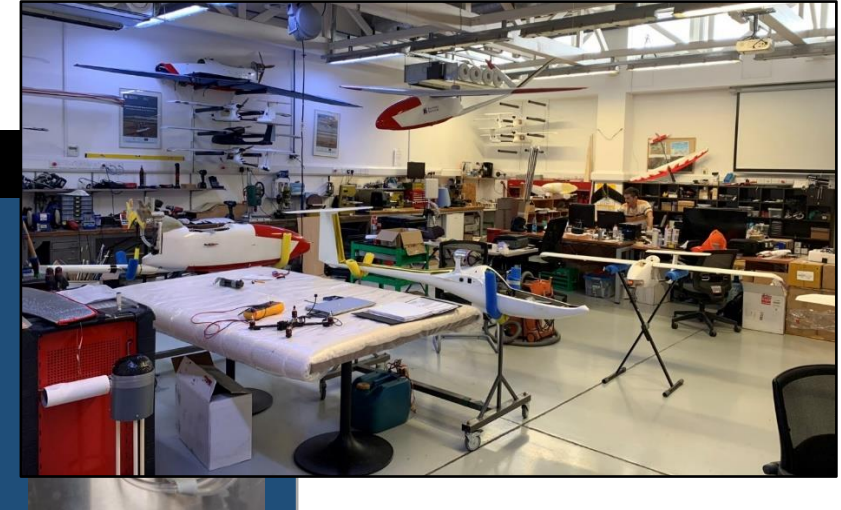
**Fabrication**



Prototype with dummy materials



Fabrication of special lightweight composite

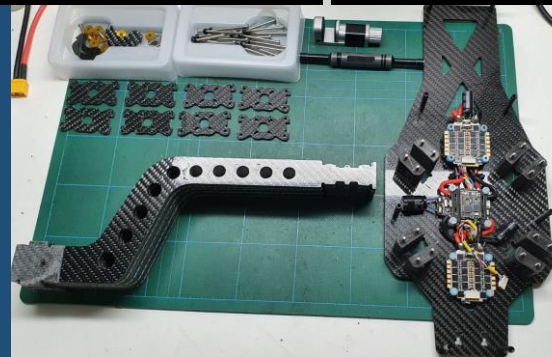


**Machining**



CNC Components Assembly  
Machining

**Assembly, Wiring, Programming**



Wiring

**Fine Tuning, Flight**



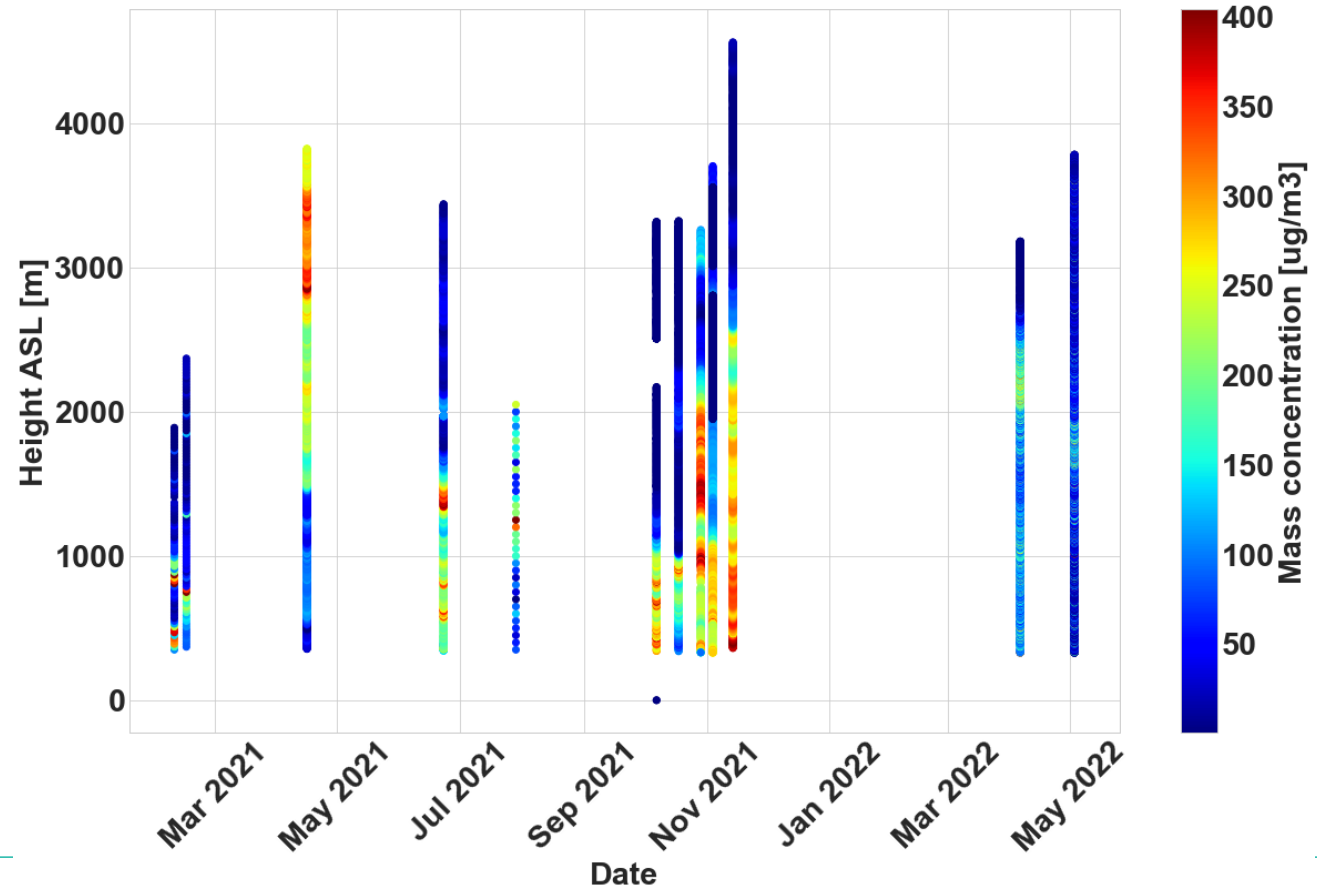
Flying

Courtesy of  
Christos Keleshis

# 1-year continuous UAV flight operation program with Vertical distribution (0-3km) of Mass concentration

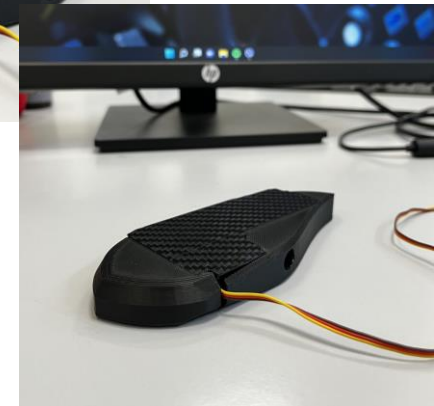
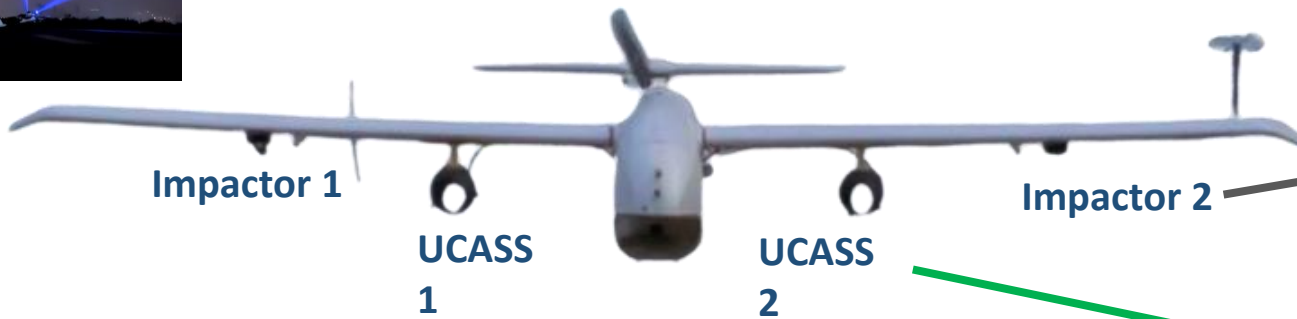






- UAV-UCASS OPC: height-resolved coarse-mode mass concentrations
- Mass concentration: different from ground and high altitude layers – high dust levels at higher altitudes (above 2000 m ASL)



Courtesy of Maria Kezoudi

# UAV sensors for dust and other aerosols

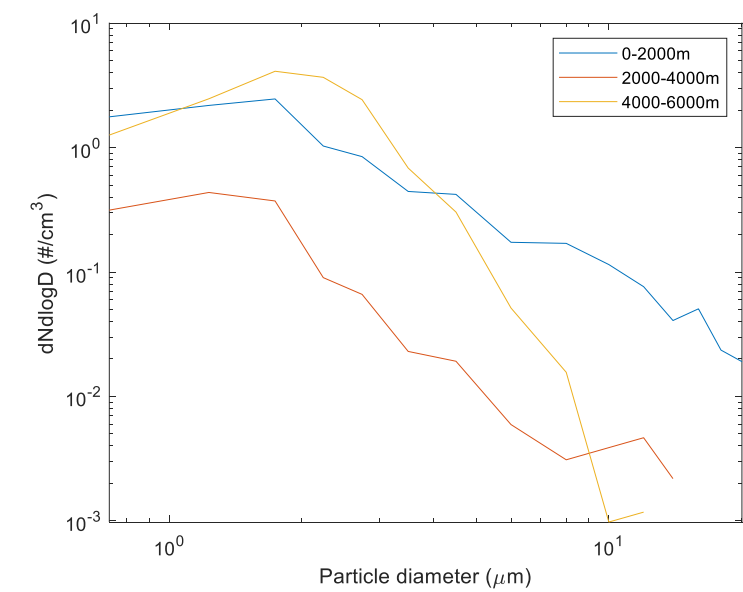
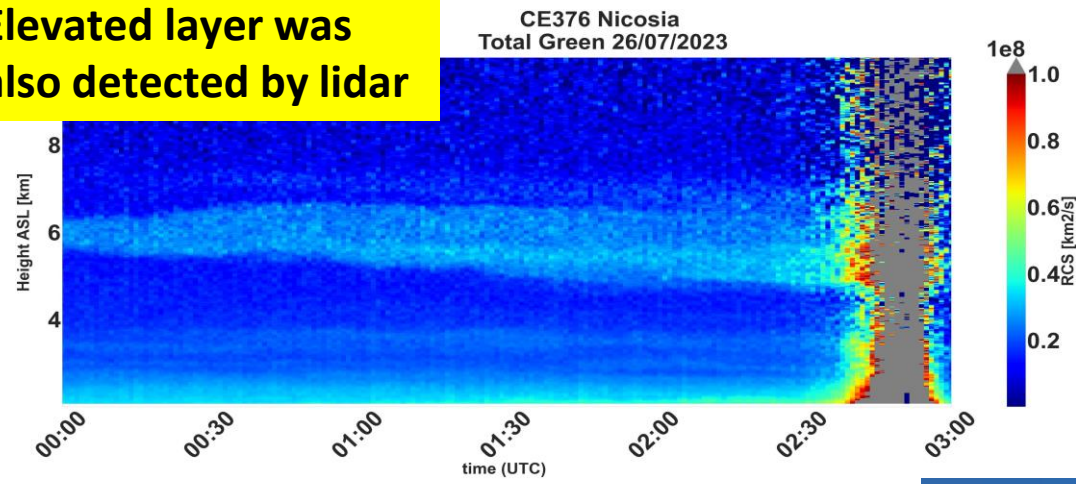
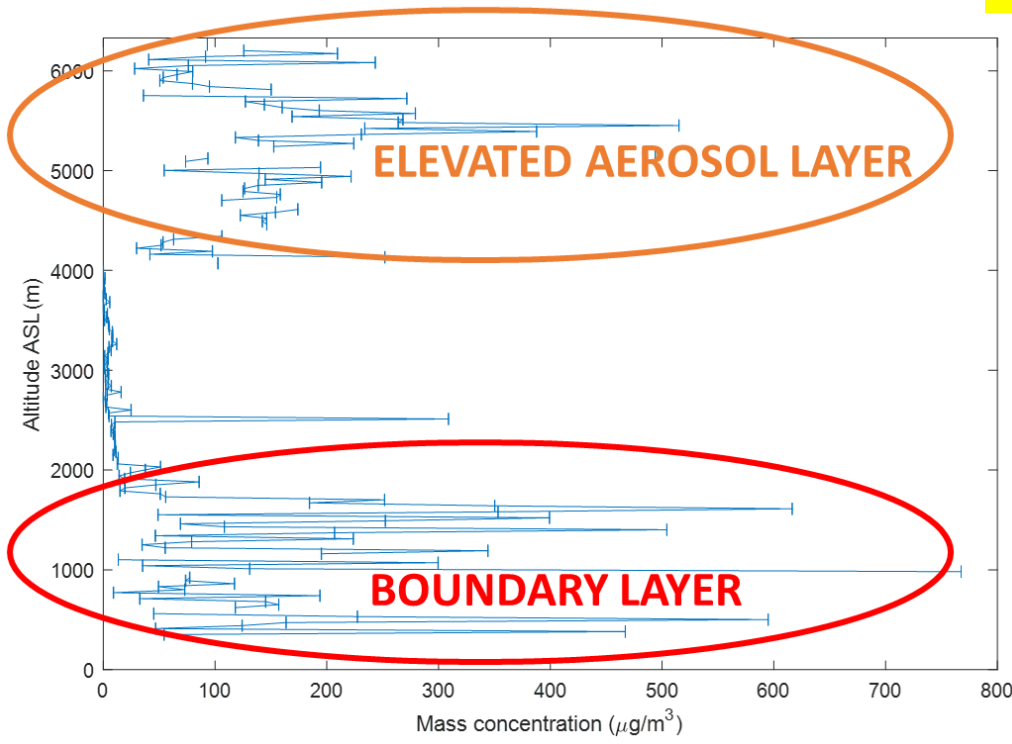


<b>SENSOR</b>	UCASS 	GPAC 	COBALD 	POPS 
<b>USE</b>	Aerosol size distribution 0.4–20 // 3–40 $\mu\text{m}$	Impactors ( $>1\mu\text{m}$ )	Backscatter ratio (2 orientations)	Aerosol size distribution 0.14–3.3 $\mu\text{m}$

# UAV-Balloon UCASS flight (26.07.2023)



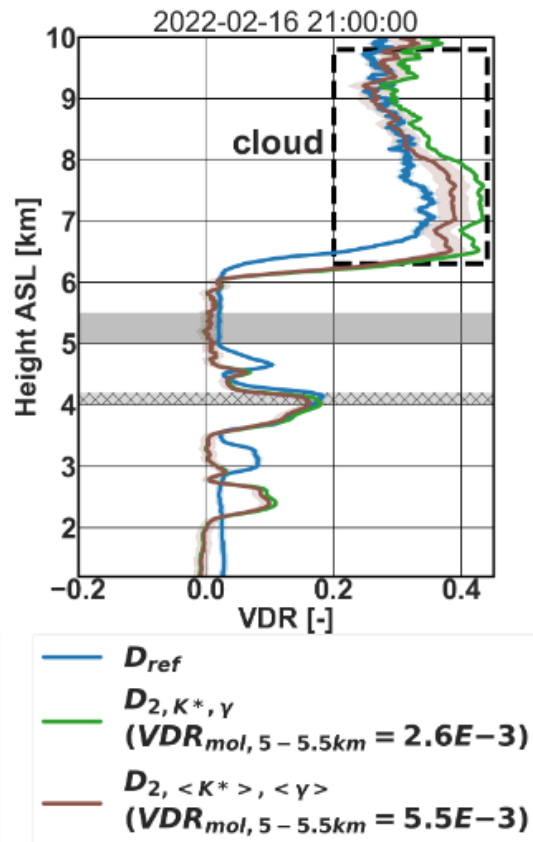
Elevated layer was also detected by lidar





Courtesy of Maria Kezoudi



# Collaboration with ERATOSTHENES (CARO)



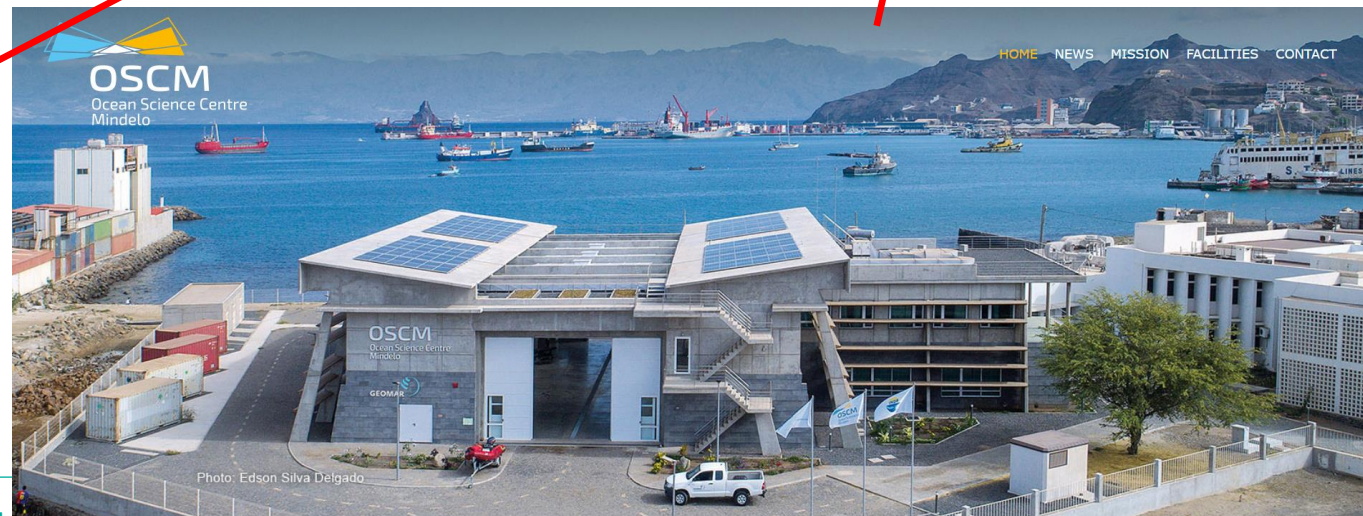
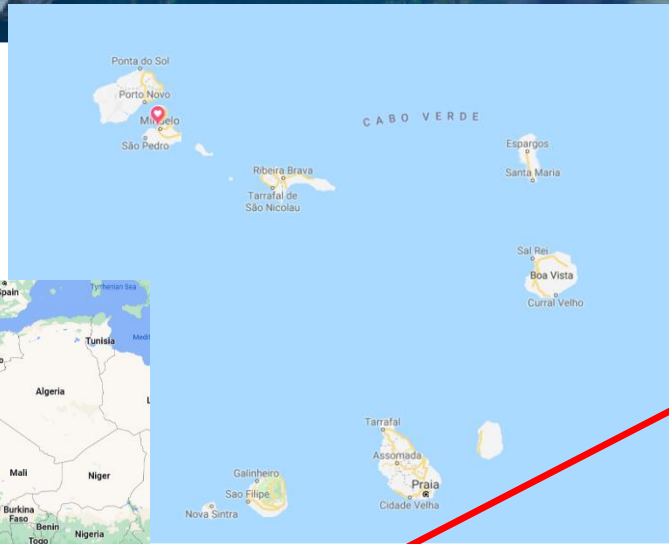
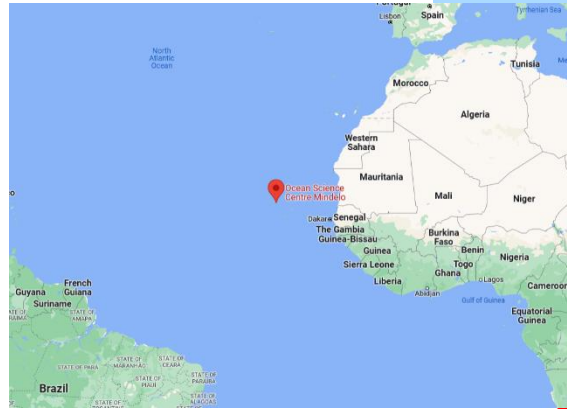
**MEMORANDUM OF UNDERSTANDING ("MoU") BETWEEN  
CLIMATE AND ATMOSPHERE RESEARCH CENTER (CARE-C)  
AND  
ERATOSTHENES CENTRE OF EXCELLENCE (ERATOSTHENES CoE)**

The Climate and Atmosphere Research Center (CARE-C) represented by its Director Prof. Jean Sciare, and the Eratosthenes Centre of Excellence (ERATOSTHENES CoE) represented by its Managing Director Prof. Diofantos Hadjimitsis, considering that the development of a direct scientific collaboration would be of mutual advantage to both, agree to the following:

# CARE-C and CARO Observational Facilities



# ASKOS Campaign: (10–30 June 2022)



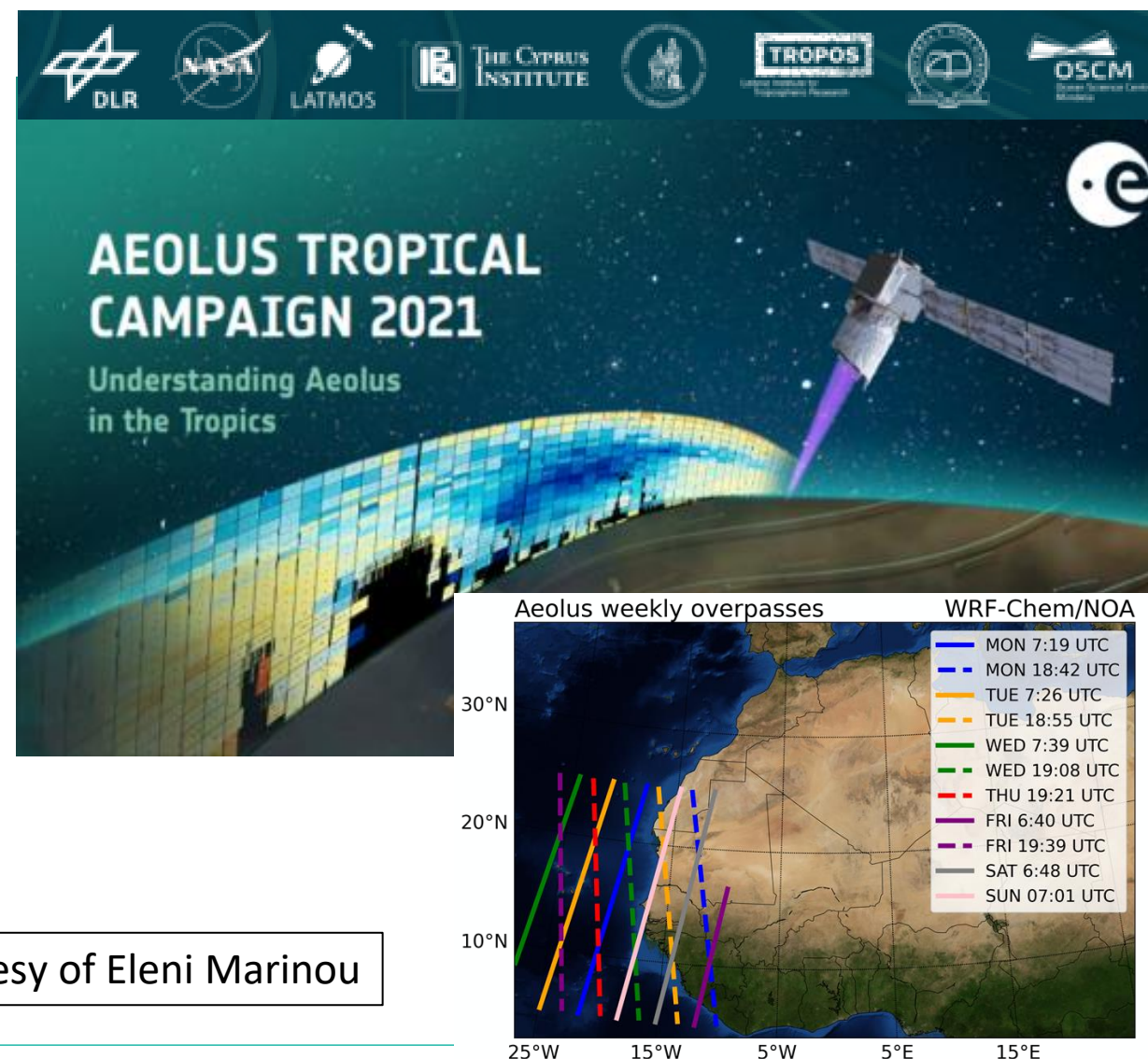


## ASKOS is the ground base component of Aeolus Tropical campaign 2021 (June, July)

### ASKOS Objectives:

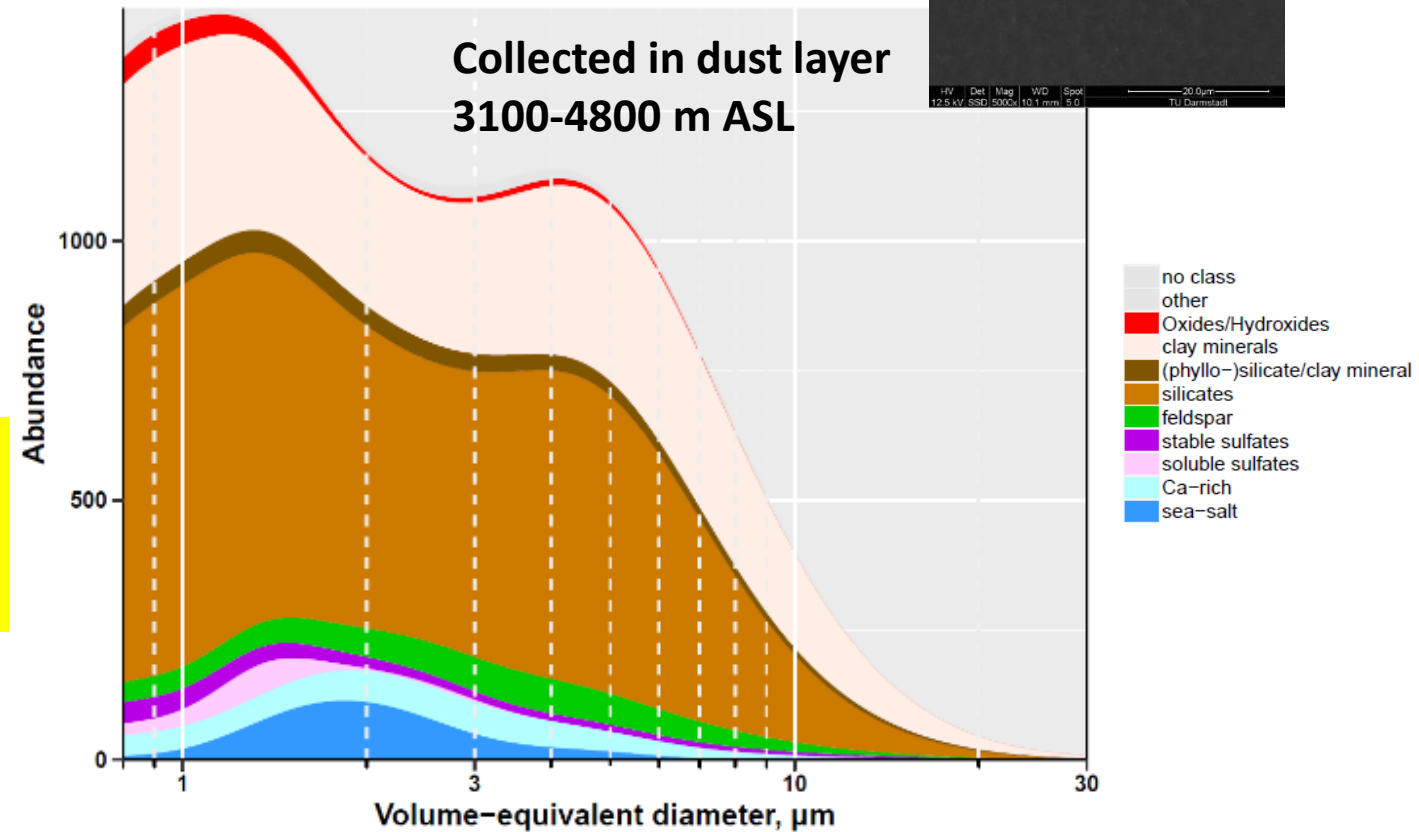
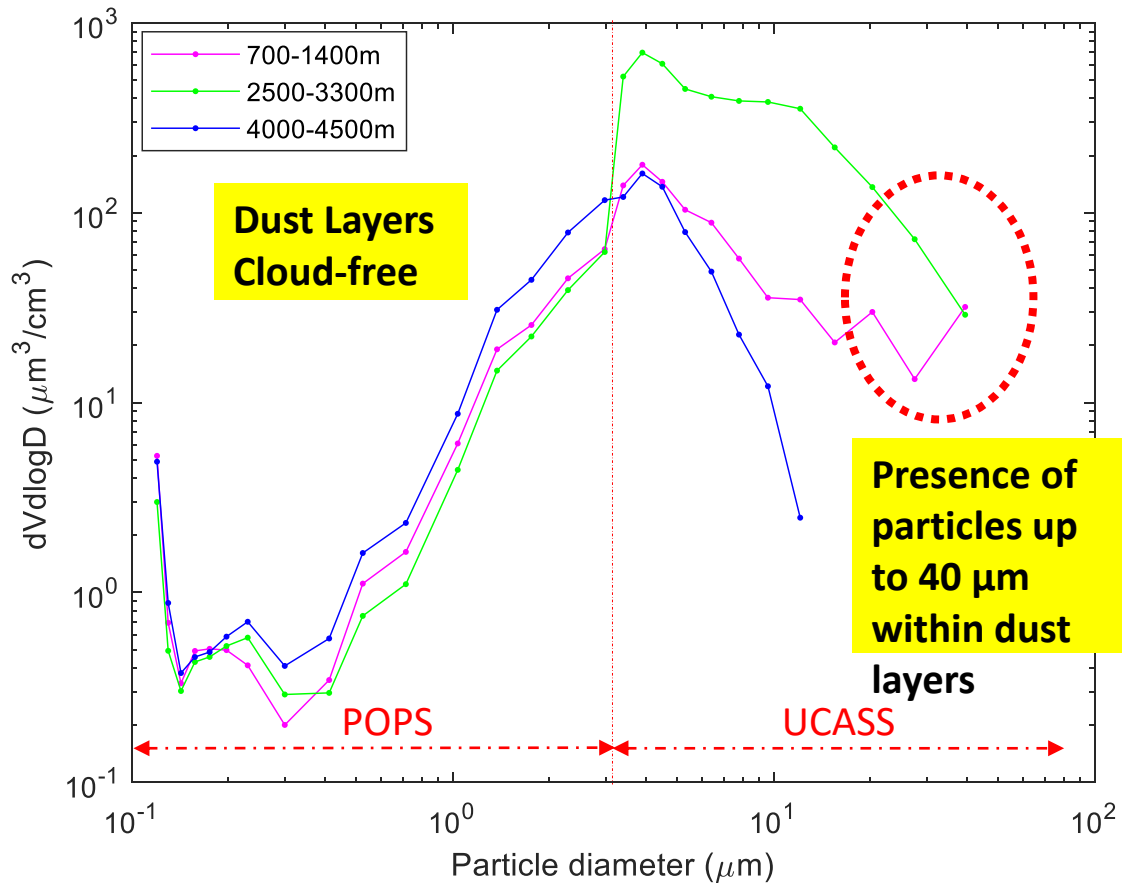
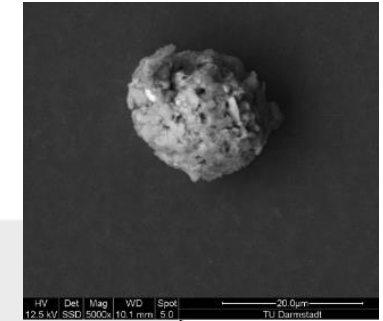
- To **evaluate the Aeolus L2A aerosol and cloud product** performance for dust/marine aerosols
- To estimate the uncertainty in the Aeolus backscatter caused by the **undetected cross-polar signal** return from non spherical particles
- To **estimate the impact of particle orientation** in Aeolus products for mineral particles and ice crystals
- To provide an unprecedented amount of **quality assured datasets** for evaluating more Aeolus applications (e.g. improvements in desert dust modeling and sea salt emission estimations).

Courtesy of Eleni Marinou

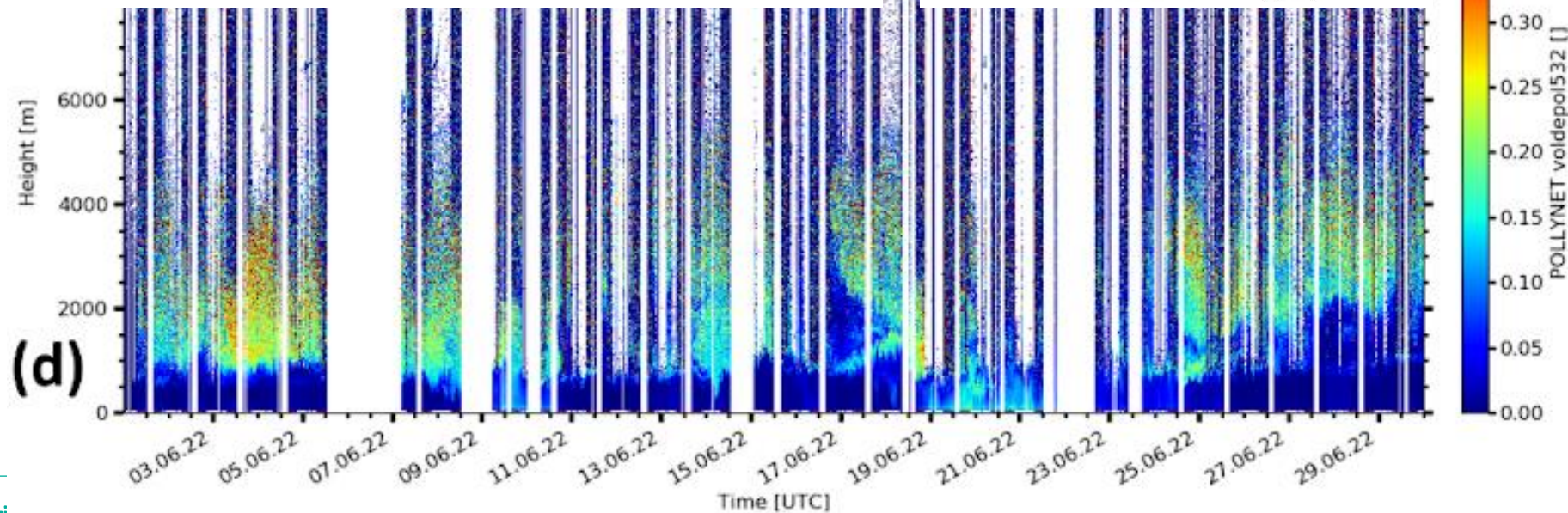
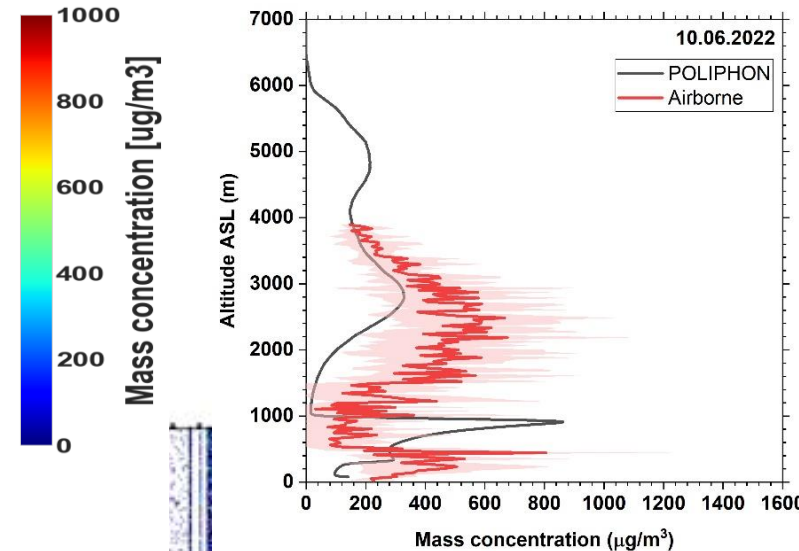
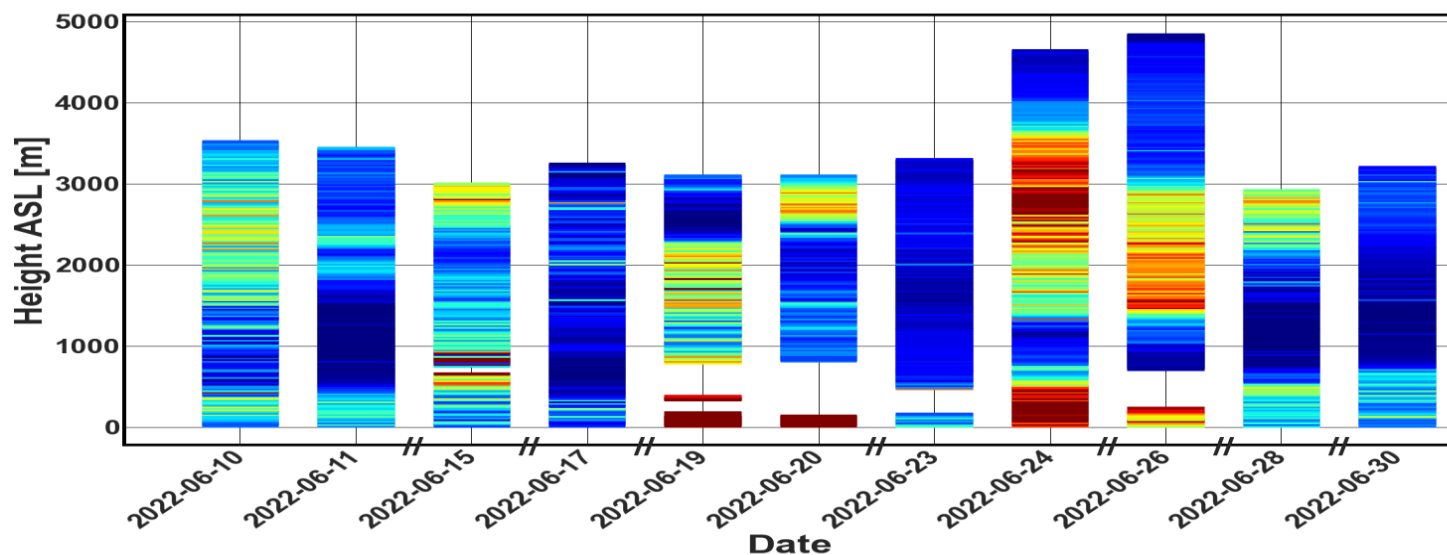


## Case study: 24.06.2022

Courtesy of Maria Kezoudi and Konrad Kandler



# Mass Concentration Profiles - UCASS



Courtesy of Maria Kezoudi,  
Alkistis Papetta and TROPOS



## EarthCARE CalVal

**Title**  
Cyprus Observations for EarthCare va

**Type**  
EarthCARE CalVal AO call

**Class**  
CAL/VAL - Quality

**Cost**  
Free of Charge

**Primary Application Domain**  
Calibration/Validation

**Location**  
Cyprus

### Executive Summary

The objective of this proposal is to validate the EarthCARE cloud and aerosol products (supplementary geophysical products) and the related instrument calibration modes and algorithms. The validation will be performed with ground-based Raman/polarization lidar and radar instruments in Limassol by CARO facility of ERATOSTHENES Centre of Excellence, providing unbiased profiles of particle extinction, optical depth, backscatter, extinction-to-backscatter ratio and linear and circular depolarization ratios for clouds and aerosol. Moreover, observations performed at the Cyprus Atmospheric Observatory (CAO) will be exploited: polarization lidar in Nicosia, as well as ceilometers and sunphotometers at three stations (Nicosia, Agia Marina Xyllatou, and Troodos). These observations will be complemented with high-altitude in-situ aerosol observations with optical particle counters, impactors and backscattersonde. The latter observations will exploit the drones of the Unmanned Systems Research Laboratory (USRL). Both CAO and USRL are operated by the Cyprus Institute (Cyi).

Collocated measurements will be performed during ground and airborne campaigns, planned to be carried in Cyprus as an initiative of the ERATOSTHENES Centre of Excellence (ERATOSTHENES CoE) and the Climate and Atmosphere Research Center (CARE-C) of The Cyprus Institute (Cyi). In terms of funding, the monitoring activities by ERATOSTHENES are implemented in the framework of the EXCELSIOR Teaming project supporting the establishment of the ERATOSTHENES CoE, and the stations' participation in European Networks (EARLINET, Cloudnet) and the ACTRIS RI or AERONET. For the activities of USRL and CAO, funding will need to be sought through national and/or international funding opportunities.

Moreover, the cal/val experiments will be synchronized with the experiments scheduled for the needs of the Teaming project EXCELSIOR, which is under implementation by the organization involved. ERATOSTHENES CoE plans to allocate in the future additional funds to support and cover the expenses for the operation of the observational and mobile facilities on EarthCARE ground-track and for accomplishing the radiative closure experiments. Similarly, CARE-C/Cyi performs atmospheric observations within the framework of other funded projects, and with the goal of improving efficiency an attempt will be made to align these to the needs of the EarthCARE cal/val, when possible. Please note, in any case, that obligations and commitments stemming from this call for proposals can only be agreed upon once a funding source is found.

The overarching objective of this proposal is to perform thorough cal/val investigations on EarthCARE products over Cyprus, a region well-known for its complex atmospheric environment. The experiments will be designed such as to achieve the following core objectives:

(1) to perform a thorough validation of the EarthCARE stand-alone aerosol and clouds products, employing state-of-the-art ground-based remote sensors, spaceborne observations derived from the passive and active of the missions' payload,



**ATMO ACCESS**  
Access to Atmospheric Research Facilities

## Pilot project implementation plan ESA EarthCARE Cal/Val support

**Authors:** Holger Baars<sup>(1)</sup>, Eleni Marinou<sup>(2)</sup>, Rob Koopman<sup>(3)</sup>, Stephanie Rusli<sup>(3)</sup>, Lucia Mona<sup>(4)</sup>, Constantino Munoz Porcar<sup>(5)</sup>, Alejandro Rodriguez<sup>(5)</sup>, Ewan O'Connor<sup>(6)</sup>, Martial Haeffelin<sup>(7)</sup>, Michael Sicard<sup>(8)</sup>, Patric Seifert<sup>(1)</sup>, Vassilis Amiridis<sup>(2)</sup>, Ann Mari Fjæraa<sup>(9)</sup>, Doina Nicolae<sup>(10)</sup>

- 1) Leibniz Institute for Tropospheric Research (TROPOS), Leipzig, Germany
- 2) National Observatory of Athens, Athens, Greece
- 3) European Space Agency (ESA – ESTEC), Noordwijk, the Netherlands
- 4) National Research Council of Italy, Institute of Methodologies for Environmental Analysis (CNR-IMAA), Potenza, Italy
- 5) Dept. of Signal Theory and Communications, Remote Sensing Lab. (RSLab), Universitat Politècnica de Catalunya, Barcelona, Spain
- 6) Finnish Meteorological Institute, Helsinki, Finland
- 7) Institut Pierre Simon Laplace (IPSL), CNRS, École Polytechnique, Institut Polytechnique de Paris, France
- 8) Laboratoire de l'Atmosphère et des Cyclones (LACY), University of La Reunion, France
- 9) Norwegian Institute for Air Research (NILU), Norway
- 10) National Institute of R&D for Optoelectronics (INOE), Romania

**Date:** 2023-05-15



This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

[atmo-access.eu](https://atmo-access.eu)

# ATMO-ACCESS pilot “rehearsal” campaign

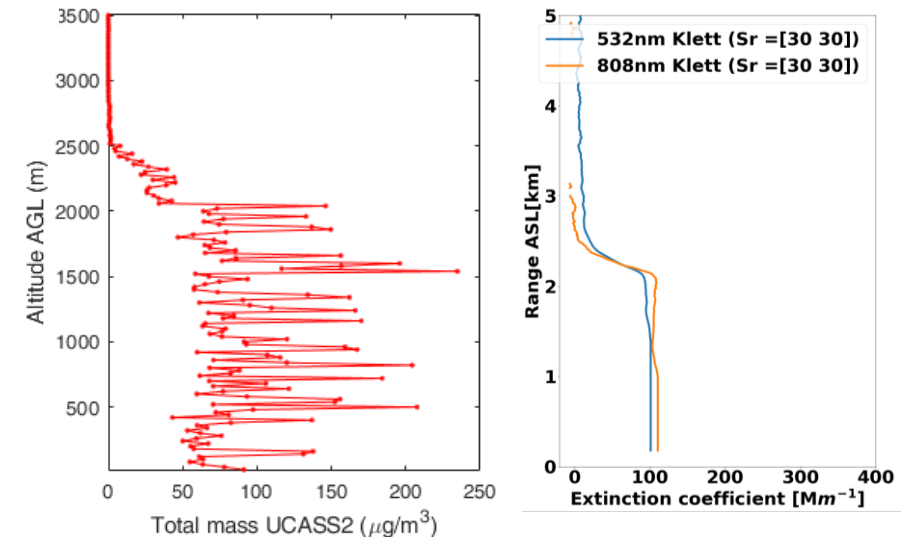


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Pilot project implementation plan  
ESA EarthCARE Cal/Val support

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- EVDC-compliant datafiles generated
- Lidar data submission to EVDC started Sep 2023
- First UAV flights on 25 Oct and 3 Nov 2023; data submission to EVDC as soon after landing (dusty conditions)







**ATMO ACCESS**  
Access to Atmospheric Research Facilities

## Pilot project implementation plan ESA EarthCARE Cal/Val support

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 9) Norwegian Institute for Air Research (NILU), Norway  
 10) National Institute of R&D for Optoelectronics (INOE), Romania

**Date:** 2023-05-15

- Main campaign: April – September 2024
- Attractive observations infrastructure in Cyprus (CAO, USRL and CARO): complementary observations for cal/val

Work packages		2023							2024								
		June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16
<b>WP 1</b>	<b>Preparation of network rehearsal campaign</b>																
<b>WP 2</b>	<b>Network rehearsal campaign</b>																
Event: EarthCARE workshop Frascati																	
<b>WP 3</b>	<b>Preparation of Cal/Val campaign</b>																
Event: EarthCARE rehearsal																	
Event: EarthCARE launch																	
<b>WP 4</b>	<b>Cal/Val campaign</b>																
<b>WP 5</b>	<b>Intercalibration with reference systems</b>																



Consejería de Transformación Económica,  
Industria, Conocimiento y Universidades  
Secretaría General de Universidades,  
Investigación y Tecnología

## MEMORIA CIENTÍFICO-TÉCNICA

Convocatoria de subvenciones a «proyectos de I+D+i» universidades y entidades públicas de investigación (BOJA n.º239, de 15 de diciembre de 2021 )

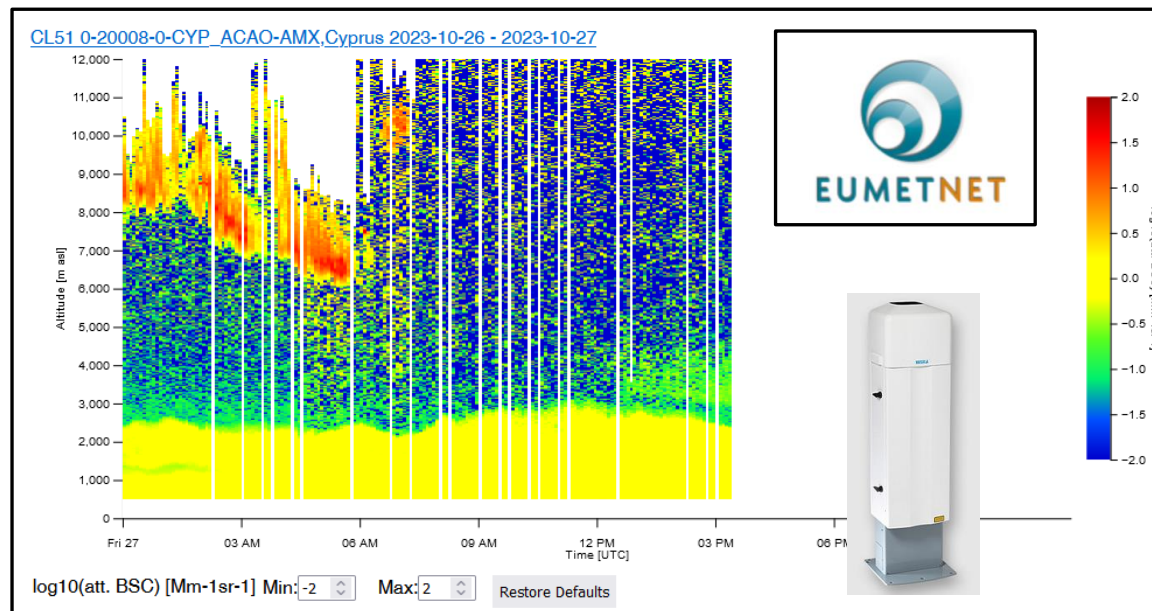
Organismo/Universidad	Universidad de Granada
Persona investigadora principal	Francisco Navas Guzmán
Denominación del proyecto	Improving the Atmospheric aEROSol MONITORING in a continental-scale by the Synergy of passive and active remote sensing Techniques (AEROMOST)
Modalidad del proyecto	Investigador consolidado

Se incluirá junto con la solicitud una memoria científico-técnica, que deberá contener, entre otros los siguientes epígrafes:

### 1. RESUMEN DE LA PROPUESTA - ABSTRACT

Anthropogenic aerosols are responsible for a radiative forcing of climate through multiple processes including aerosol-radiation interactions and aerosol-cloud interactions and contribute to the degradation of the air quality, with relevant effects on human health. The lack of vertical profiles of aerosol properties with high-spatial and temporal resolution over wide regions is highlighted in the last three IPCC (Intergovernmental Panel on Climate Change) reports as the contribution to the global radiative budget subject to the largest uncertainties. For that, information on the large scale 4-dimensional aerosol distribution in the atmosphere should be continuously monitored. Multi-wavelength Raman lidars have emerged as a good tool for the characterization of aerosol vertical properties. However, they are generally expensive and require supervision, so this causes the number of measurements, and their spatial coverage is scarce. In order to monitor aerosol in a global scale, there is a need for denser networks that could provide information on the 4D distribution of atmospheric aerosol. The developments of ceilometers with profiling capabilities as well as advances in the calibration techniques related to such devices offer the opportunity of implementing dense and continuously operating ground-based networks for the detection and quantification of aerosol. This global scale information is crucial for improving the existing aerosol models. This project aims to monitor vertical profiles of aerosol optical and microphysical properties with high spatial and temporal resolution in a global scale. For that, we will develop and establish a system capable to assimilate column-integrated aerosol properties from sun/sky photometers and aerosol vertical profiles from lidars to apply GRASP inversion algorithm. The aerosol products from this system will provide near-real-time vertically-resolved and columnar aerosol properties in a global scale. A first approach will be implemented using the measurements from the ground-based networks of AERONET (sun/sky photometers) and E-PROFILE (ceilometers) which will be used as input data of GRASP. This will allow obtaining the densest network of aerosol vertical properties in Europe. A second approach will use different datasets since the AERONET measurements will be combined with the vertical aerosol measurements from ATLID lidar on board of EarthCARE satellite. This second approach will allow providing a global aerosol monitoring around the world and in addition we will validate and add some new products to the EarthCARE mission. Evaluation of the different aerosol products from the two proposed approaches will be carried out comparing with independent measurements using sophisticated Raman lidars and other inversion algorithms. In addition, intensive field campaigns are planned at the supersite of Granada station

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<https://juntadeandalucia.es/organismos/transformacioneconomiaindustriaconocimientoyuniversidades.html>





## ACROSS Mediterranean campaign locations

**3 Intensive Observational Periods of 3 months each, including targeted large-scale field experiments in the Mediterranean**

**Set up will follow ASKOS example:**

- ACTRS Aerosol and Cloud remote sensing facilities in Potenza/Italy, Cyprus and PANGEA/Greece.
- Radiation remote sensing measurements for closure studies
- UAV in-situ flights collocated with the RS measurements

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## ACROSS objectives

EarthCARE Cal/Val experiment over the Mediterranean region

The Mediterranean basin provides the complex aerosol-cloud environment needed for EarthCARE for an extended activity that would increase synergies towards achieving the following objectives:

1. To validate the EarthCARE aerosol and cloud products using state-of-the-art ground-based facilities
2. To implement science studies targeting radiation closure studies and data assimilation experiments
3. To provide information for harmonizing and bridging past and future missions, to deliver Climate Data Records on aerosols and clouds (focusing over the ESA-LIVAS CDR)

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- The ATMO-ACCESS pilot provides support to our cal/val activity until Autumn 2024 (provision of lidar and UAV datasets, coincident with EarthCARE overpasses)
- It is our ambition to be able to continue EarthCARE cal/val beyond the ATMO-ACCESS pilot (CORAL, AEROMOST and ACROSS projects): *funding-dependent*

Thanks for your attention!



Title

