The Cyprus Institute contribution to the ASKOS Aeolus Tropical Campaign

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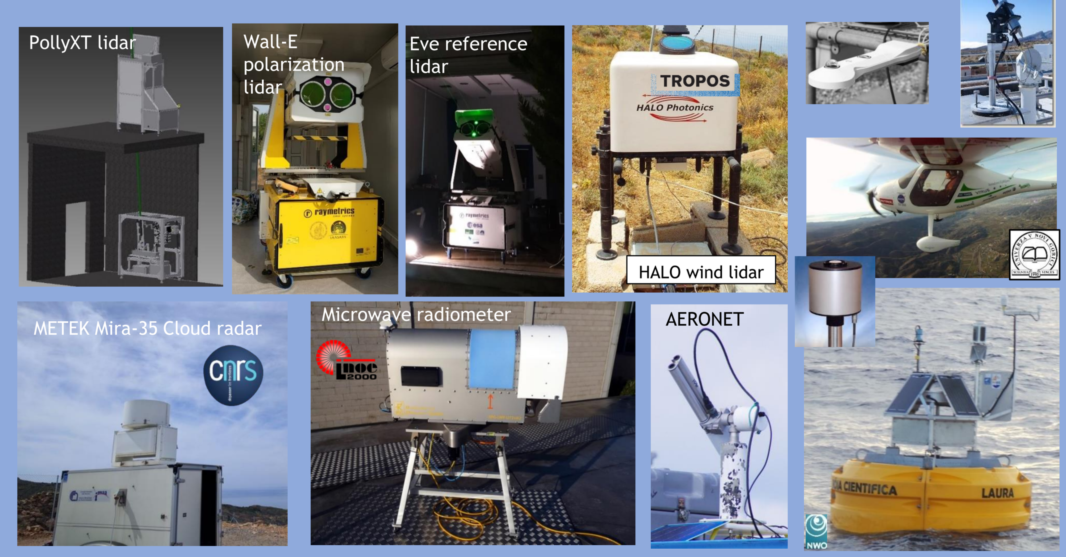
The ASKOS experimental campaign serves as the ***ground-based component of the Aeolus Tropical campaign*** *and is based in Mindelo (Cape Verde). ASKOS targets the quality assessment of the Aeolus satellite aerosol, cloud and wind products. The campaign started in June 2021 and will see its "full phase" deployed in the* ***summer of 2022****, when a set of aerosol, cloud, wind, radiation, polarization and cloud remote sensing instruments will be deployed together with airborne platforms.*

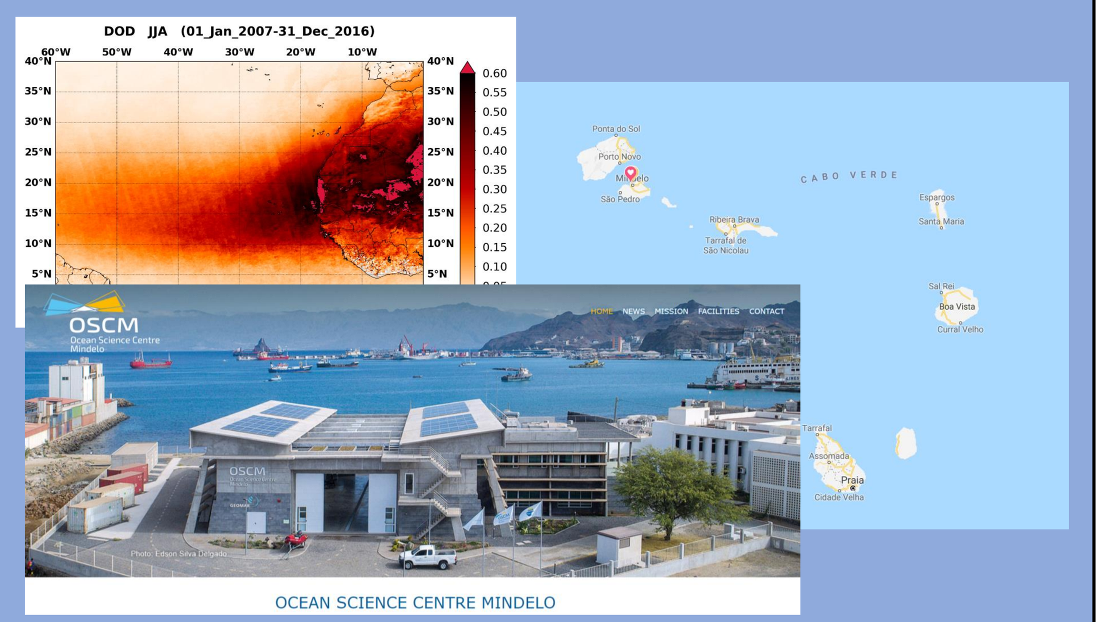
The Cyprus Institute develops, adapts and optimises novel unmanned aerial vehicles (UAVs) and sensors for dedicated atmospheric campaigns. One of the missions of the institute's ***Unmanned Systems Research Laboratory*** *is to leverage its unique research infrastructure to document long range transported pollution from three continents (Europe, Africa and West Asia) and dust aerosols from the largest desert regions in the world (Sahara, Middle East). Its facilities are moreover a new mobile exploratory platform of the EU Research Infrastructure Aerosol, Clouds and Trace Gases Research InfraStructure (ACTRIS).*

In this presentation we will give an overview of the Cyprus Institute's contribution to ASKOS and the tropical campaign. The UAV platform will be deployed with ***optical particle counters, backscatter sondes, and impactors*** *able to collect dust samples. The aim is to fly regularly at altitudes up to 6,000 m, exploiting new technologies including a novel UAV-balloon upgrade. We will also present preliminary results of a preparatory campaign performed in fall 2021 in Cyprus. During this campaign, we operated 33 UAV flights between mid-October and mid-November, capturing two dust events lasting about a week each. This preparatory campaign served to optimise our drones and instruments, and to strengthen their operations, and to enhance the UAV-based in-situ data exploitation against co-located ground-based remote sensing observations.*

ASKOS campaign objectives:

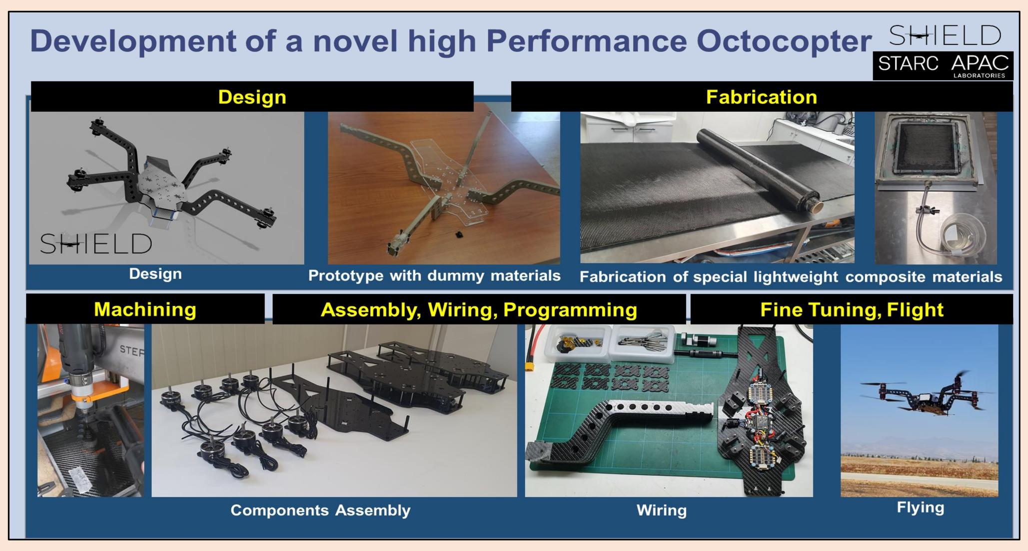
- To **evaluate the Aeolus L2A aerosol and cloud product**.
- To estimate the uncertainty in the Aeolus backscatter caused by the **undetected cross-polar signal** return from dust particles.
- To **estimate the impact of particle orientation** in Aeolus products for mineral particles and ice crystals.
- To provide **quality assured datasets** for a number of applications (e.g. improvements in desert dust modelling and sea salt emission estimations).

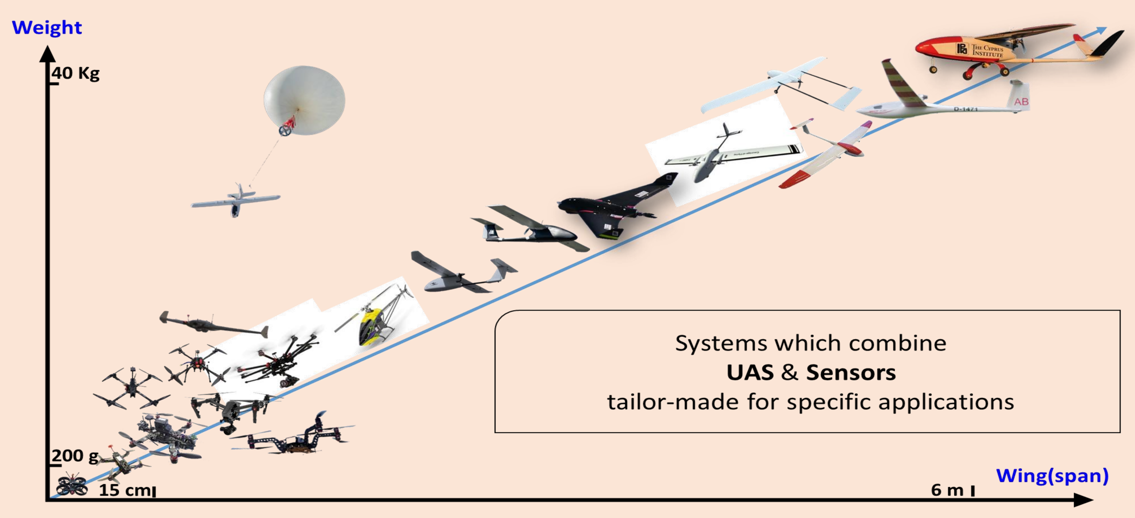




The Unmanned Systems Research Laboratory (USRL)

The mission of USRL is (1) the service provision and support to research projects which require the utilization of specialized Unmanned Aerial Systems (UAS), and (2) the development of cutting edge technology in the field of UAS. This advanced laboratory was established in 2009 and has grown its experience in the field of UAVs/UASs ever since. It comprises **the development of all the components of a UAS**: from the airframes to the autopilot software and the ground control station. It employs 12 specialised staff in the fields of electrical engineering, software development, composite materials, and image processing, and it is involved in a dozen of international scientific collaborations in the Eastern Mediterranean and Middle East, Northern Europe, and Brazil. In Cyprus, it benefits from its private runway and an associated reserved airspace from the surface up to an altitude of 6,000 m, and it is moreover able to relocate its activities around the world. It has provided services to Search and Rescue services, Forestry surveillance, and archaeological heritage sites. However the most important application field is for atmospheric observations, within the framework of the Cyprus Institute Climate and Atmosphere REsearch Centre (CARE-C). In particular, for the ASKOS campaign USRL will deploy for the first time a **UAV-balloon system** able to reach an altitude of 6,000 m using a balloon, and then release the UAV which can then make its way back to base whilst performing atmospheric measurements.

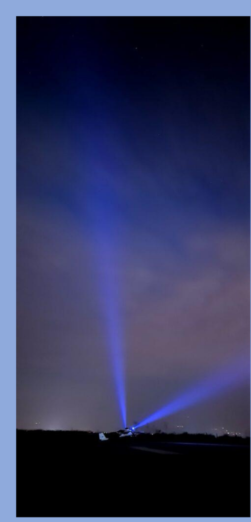




CyI contribution to ASKOS:

We will carry out **UAV flights on a daily basis up to the top of the Saharan Air Layer (5–6,000 m)**, for height-resolved observations with the following instruments:

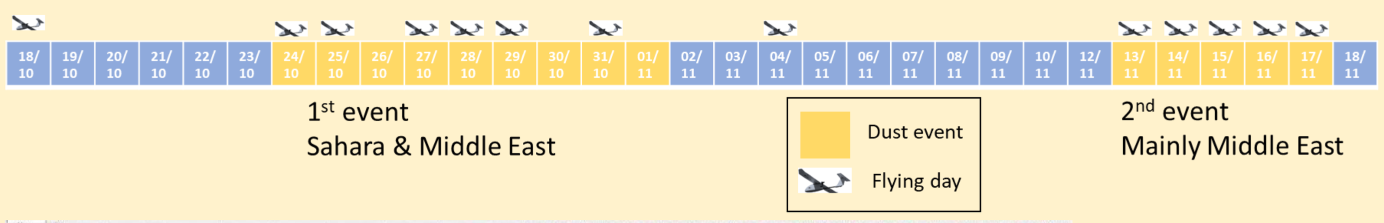
- POPS and UCASS **optical particle counters** (0.1–40 µm)
- GPAC: Impactors for **sample collection** (particles up to 100 µm)
- COBALD backscatter sondes (**particle orientation**)

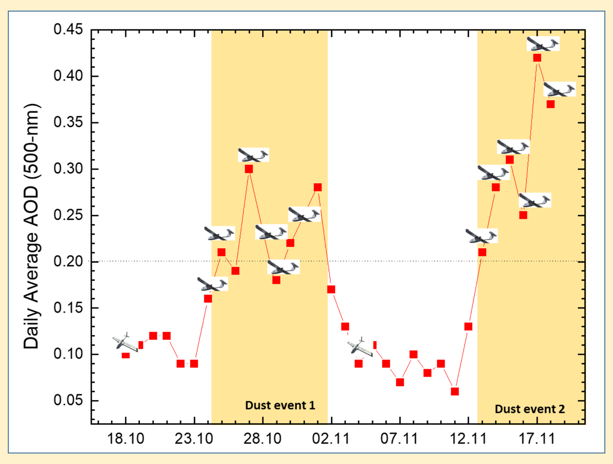


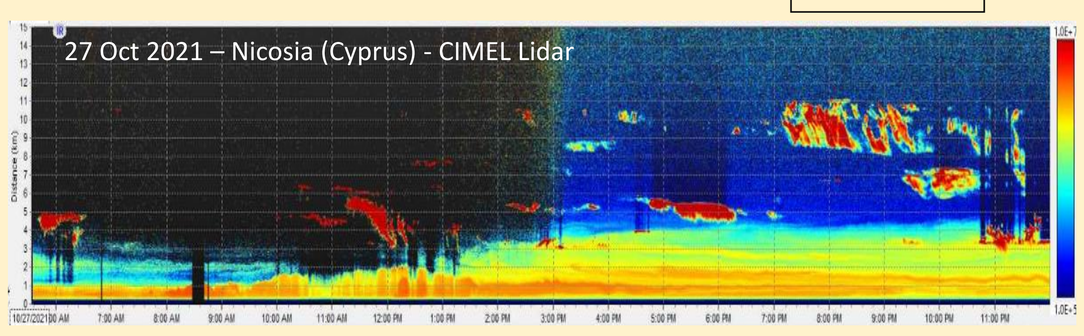
SENSOR	UCASS	GPAC	COBALD	POPS
USE	Aerosol size distribution 0.4–20 // 3–40 µm	Impactors (>1µm)	Backscatter ratio (2 orientations)	Aerosol size distribution 0.14–3.3 µm
UAV	Skywalker 2015			I-Soar

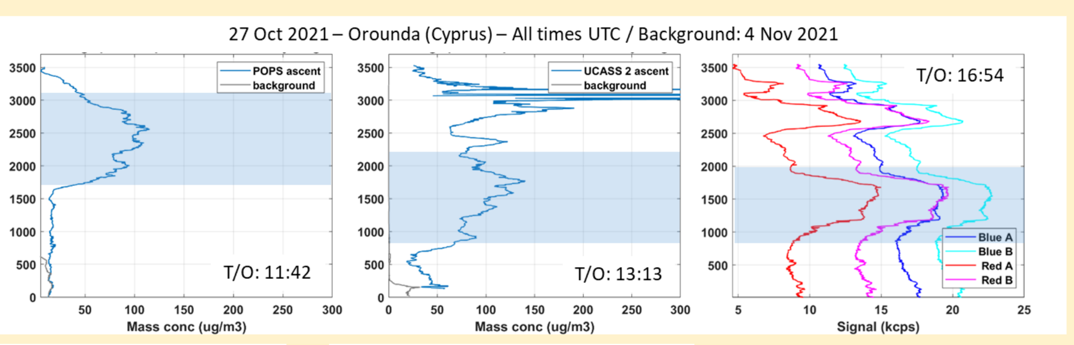
The Cyprus Fall Campaign 2021

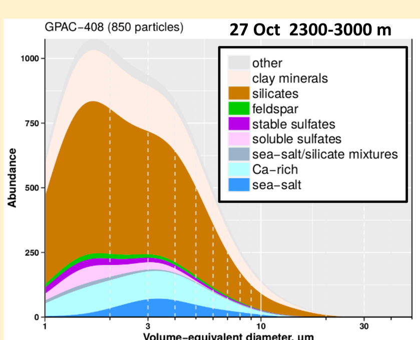
During October–November 2021, we have run an intensive campaign in Cyprus, targeting mineral dust reaching the island, originated from the nearby desert regions in the Sahara and Middle East. **The campaign served to optimise our drones and instruments, to strengthen their operations, and to enhance the UAV-based in-situ data exploitation against co-located ground-based remote sensing observations. We operated 33 research flights, and captured two dust events lasting about a week each.** The data collected can be seen in the figures below, including continuous lidar remote sensing, UAV-based profiling with different instruments, and the first results of the analysis of collected samples. The datasets will be exploited for model validation and for the evaluation of the dust radiative effect.

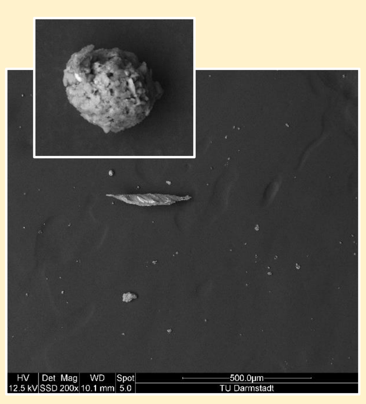


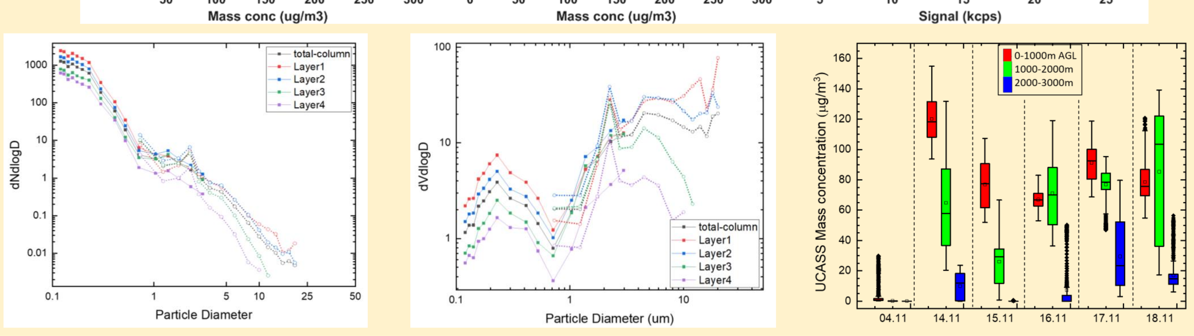


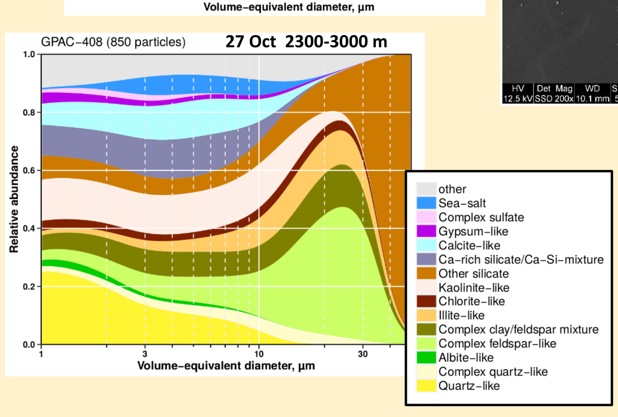








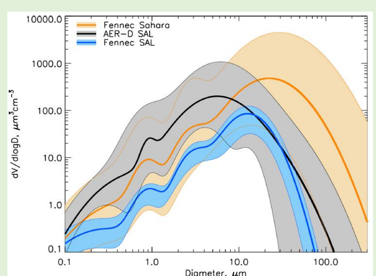


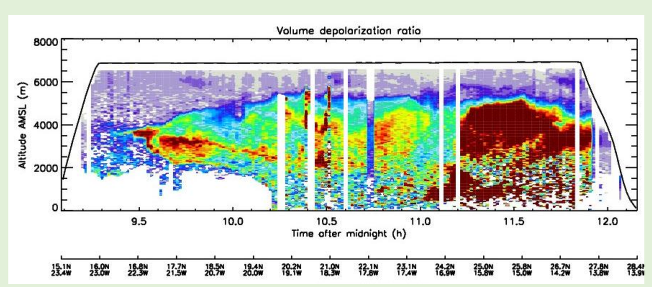


The DAZSAL proposal

Diurnal vAriation of the vertically resolved siZe distribution in the Saharan Air Layer (DAZSAL) is a proposed project making use of ATMO-ACCES transnational access. It will take advantage of the ASKOS field deployment to propose additional research flights during both day and night, with sensors able to capture the vertically resolved size distribution of mineral dust particles. The aim is to **measure the diurnal cycle of the Saharan Air Layer size-distribution for the first time**.

Recent research has revealed unexpected long-range transport of coarse dust particles, contrary to the previous assumption of swift gravitational deposition. However, there is a lack of understanding of the mechanisms which allow this long-range transport to occur. Models tend to present a fine dust bias, and this bias affects in turn the vertical and spatial distribution. A mechanism that has been suggested for the increased transport distance of coarse particles, is through convective vertical mixing within the Saharan Air Layer. The hypothesis is as follows: convective mixing during day mixes coarse particles higher in the atmosphere, enabling long-range transport and shortwave heating (larger particles being more absorbing). With the removal of the mixing driving force at night, the coarse particles are expected to sink, resulting in a different vertical size profile. Although vertical in-situ measurements of dust size distribution have been performed during day, this has never been attempted for night-time conditions. Using UAVs to create a diurnal vertically resolved size distribution dataset will be highly beneficial to our understanding of how coarse particles are lofted and deposited, and to what extent this contributes to long-range transport of coarse mineral dust. This research targets key processes with impacts on climate and health.





Reference

Kezoudi et al., "The Unmanned Systems Research Laboratory (USRL): A New Facility for UAV-Based Atmospheric Observations," *Atmosphere* (2021). https://doi.org/10.3390/atmos12081042

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