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DUST ORIENTATION MEASUREMENTS

Alexandra Tsekeri[1], Vasillis Amiridis[1], Spyros Metallinos[1], Peristera Paschou[1,2], Nikos Siomos[3], Ioanna Tsikoudi[1,4], Dimitra Kouklaki[5] and Eleni Marinou[1]

[1] IAASARS, National Observatory of Athens, Athens, Greece, [2] Laboratory of Atmospheric Physics, Physics Department, Aristotle University of Thessaloniki, Greece, [3] Fakultät für Physik, Meteorologisches Institut, Ludwig-Maximilians-Universität, Munich, Germany, [4] Department of Physics, Section of Environmental Physics-Meteorology, National and Kapodistrian University of Athens, Athens, Greece, 5 National and Kapodistrian University of Athens, Department of Geology and Geoenvironment, Athens, Greece

Overview and future steps

Dust orientation is an ongoing investigation in recent years [1; 2]. Its potential proof will be a paradigm shift for dust remote sensing, invalidating the currently used simplifications of randomly-oriented particles.

Vertically-resolved measurements of dust orientation can be acquired with the new polarization lidar “WALL-E”, designed to target the off-diagonal elements of the backscatter matrix which are non-zero only when the particles are oriented [3]. Herein, we present first measurements of WALL-E lidar acquired during the ESA Aeolus Cal/Val Campaign “ASKOS” at Cabo Verde (June and September 2022).

We acquired orientation measurements for rain, as expected, a first test of the capabilities of WALL-E lidar to provide observations of oriented particles in the atmosphere.

The dust particles in the Sahara Air Layer, for the specific cases, show small orientation signals that are within the measurement uncertainty, thus they are considered randomly-oriented.

More measurements are planned in Athens, Greece, for further investigating the phenomenon of possible dust orientation in the atmosphere

REFERENCES

[1] Ulanowski, Z., et al, Atmos. Chem. Phys., 7, 6161–6173, 2007

[2] Mallios, S., et al., J. Aerosol Sci., 151, 2021

[3] Tsekeri, A., et al, Atmos. Meas. Tech., 14, 7453–7474, 2021

ACKNOWLEDGEMENT

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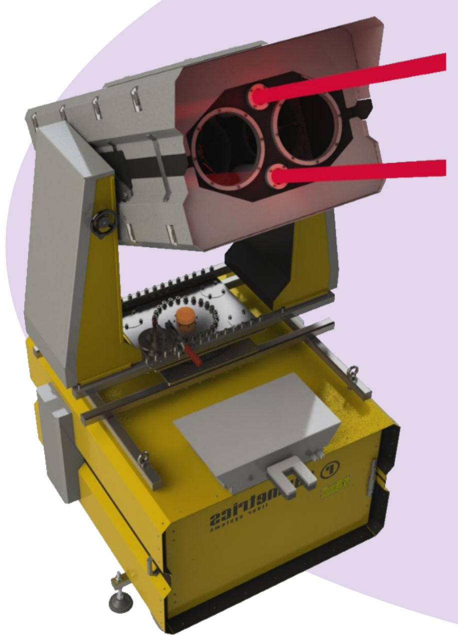
WALL-E lidar



WALL-E lidar is designed to monitor particle orientation in the atmosphere [3].

- 2 lasers: linearly- and elliptically-polarized at 1064 nm
- 2 telescopes detecting the backscattered light from both lasers. With suitable optical elements, different polarization states of the backscattered signal are measured
- Products:
  - **Orientation flags of “yes” or “no” orientation**
  - Information on dust microphysical properties *(work in progress)*
- Capability of measuring at different viewing angles (zenith and azimuth)

- **How do we detect oriented particles with a lidar?**

Backscatter matrix of randomly-oriented and oriented particles

Randomly-oriented

$$F=\begin{bmatrix} F_{11} & 0 & 0 & 0 \\ 0 & F_{22} & 0 & 0 \\ 0 & 0 & F_{33} & 0 \\ 0 & 0 & 0 & F_{44} \end{bmatrix}$$

Oriented

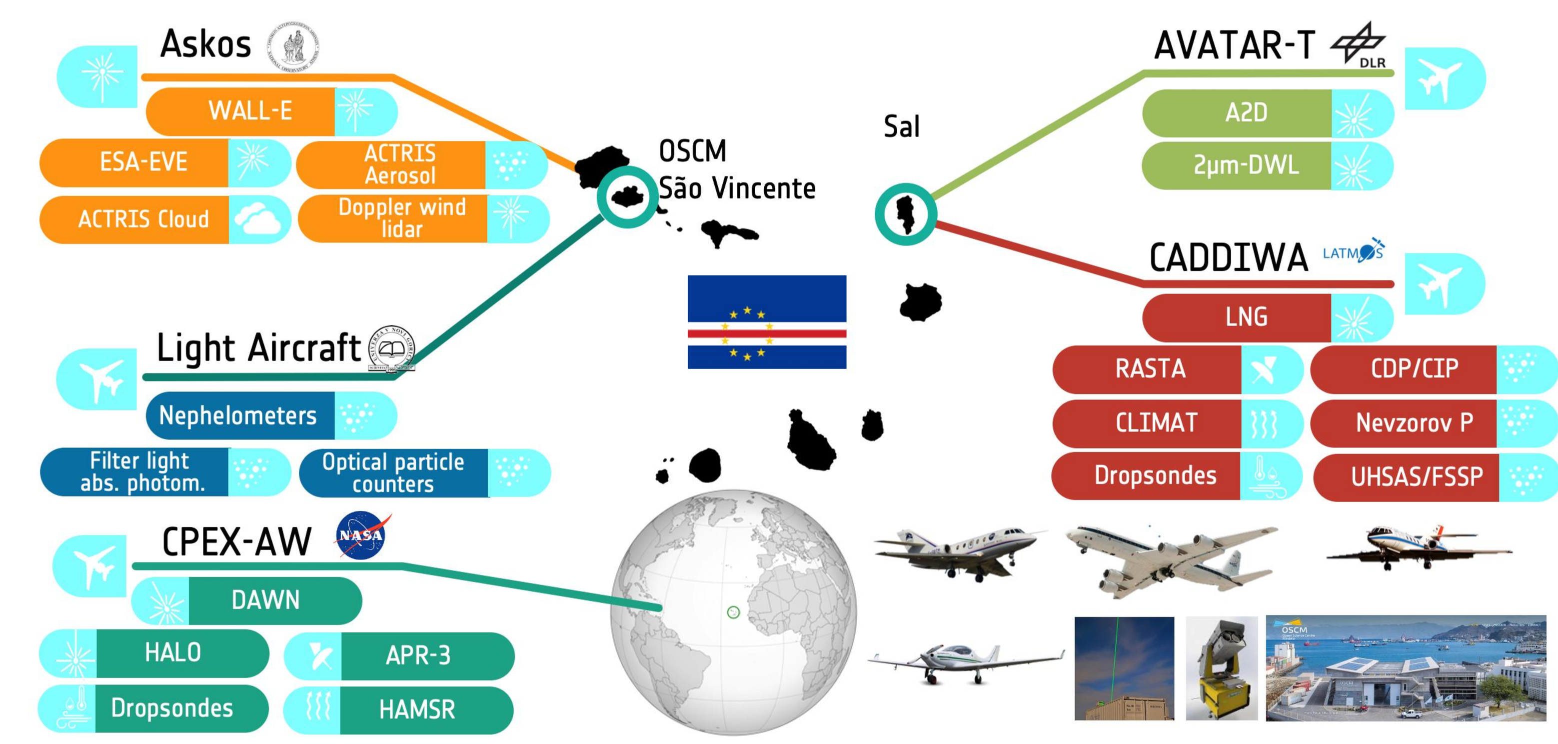
$$F=\begin{bmatrix} F_{11} & F_{12} & F_{13} & F_{14} \\ F_{12} & F_{22} & F_{23} & F_{24} \\ -F_{13} & -F_{23} & F_{33} & F_{34} \\ F_{14} & F_{24} & -F_{34} & F_{44} \end{bmatrix}$$

- Orientation will result in non-zero values of the off-diagonal elements
- These are the elements we measure with WALL-E lidar
- Specifically, with laser B we acquire the orientation flag

$$F_{LB\_TA}=\frac{1}{\eta_{TA}}\frac{I_{LB\_TA\_R}}{I_{LB\_TA\_R}}=\frac{1-f_{12}+f_{13}-f_{23}+g_{11}}{1+f_{12}+f_{13}+f_{23}+g_{11}}$$

$F_{LB\_TA}=1$ in case of no-oriented particles, whereas for oriented particles $F_{LB\_TA}\neq 1$

ASKOS ESA experimental campaign



ASKOS Science Objectives:

- AEOLUS validation
- Support to future ESA missions: EarthCARE, WIVERN
- Provide an unprecedented amount of quality assured datasets for more science applications:
  - **Investigate possible dust orientation in the atmosphere**
  - Improve desert dust models
  - Investigate dust effect on radiation and clouds

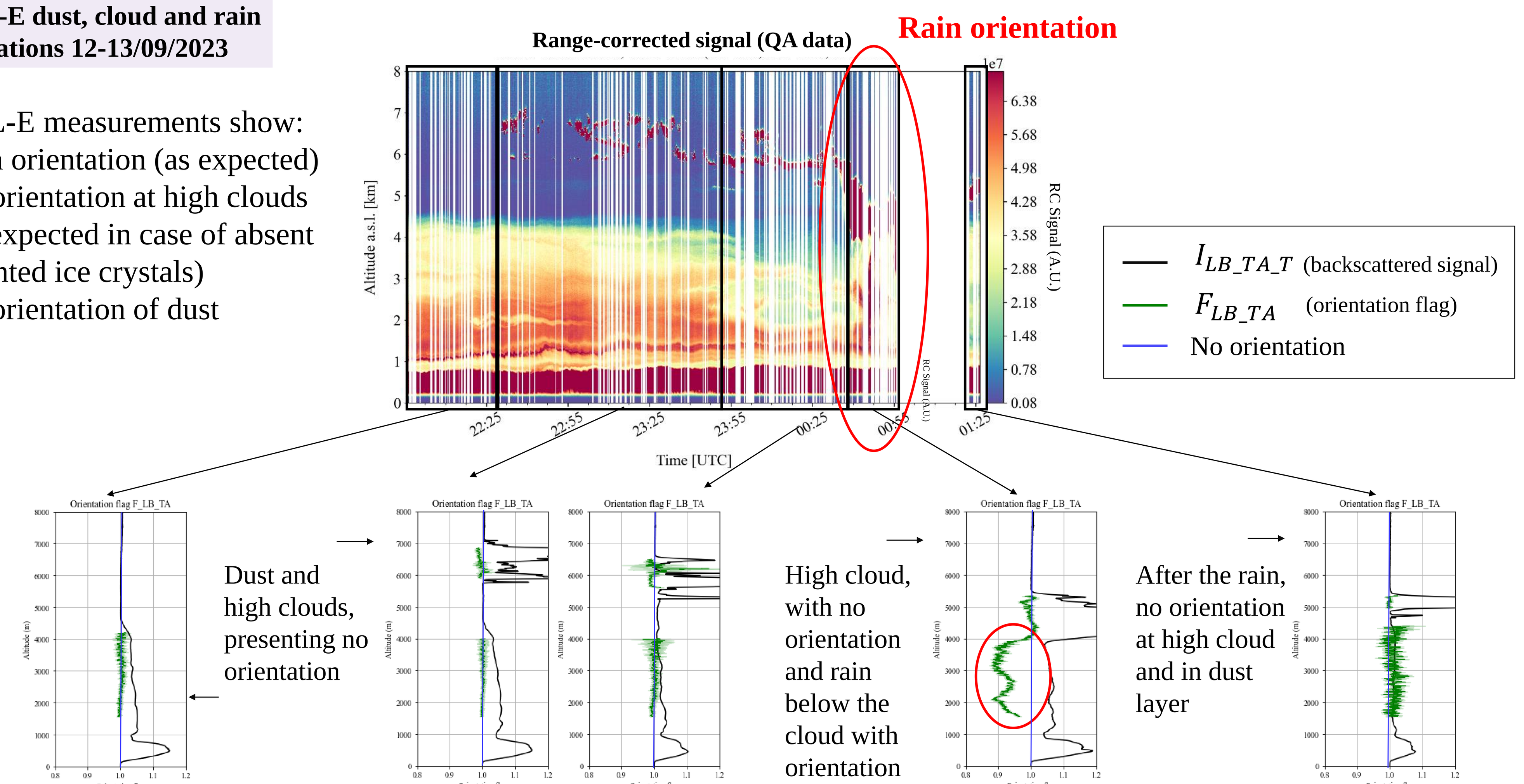
E. Marinou Oral presentation - EGU23-16530 – AS1.37
ASKOS Campaign 2021/2022: Overview of measurements and applications

Rain orientation

WALL-E dust, cloud and rain observations 12-13/09/2023

WALL-E measurements show:

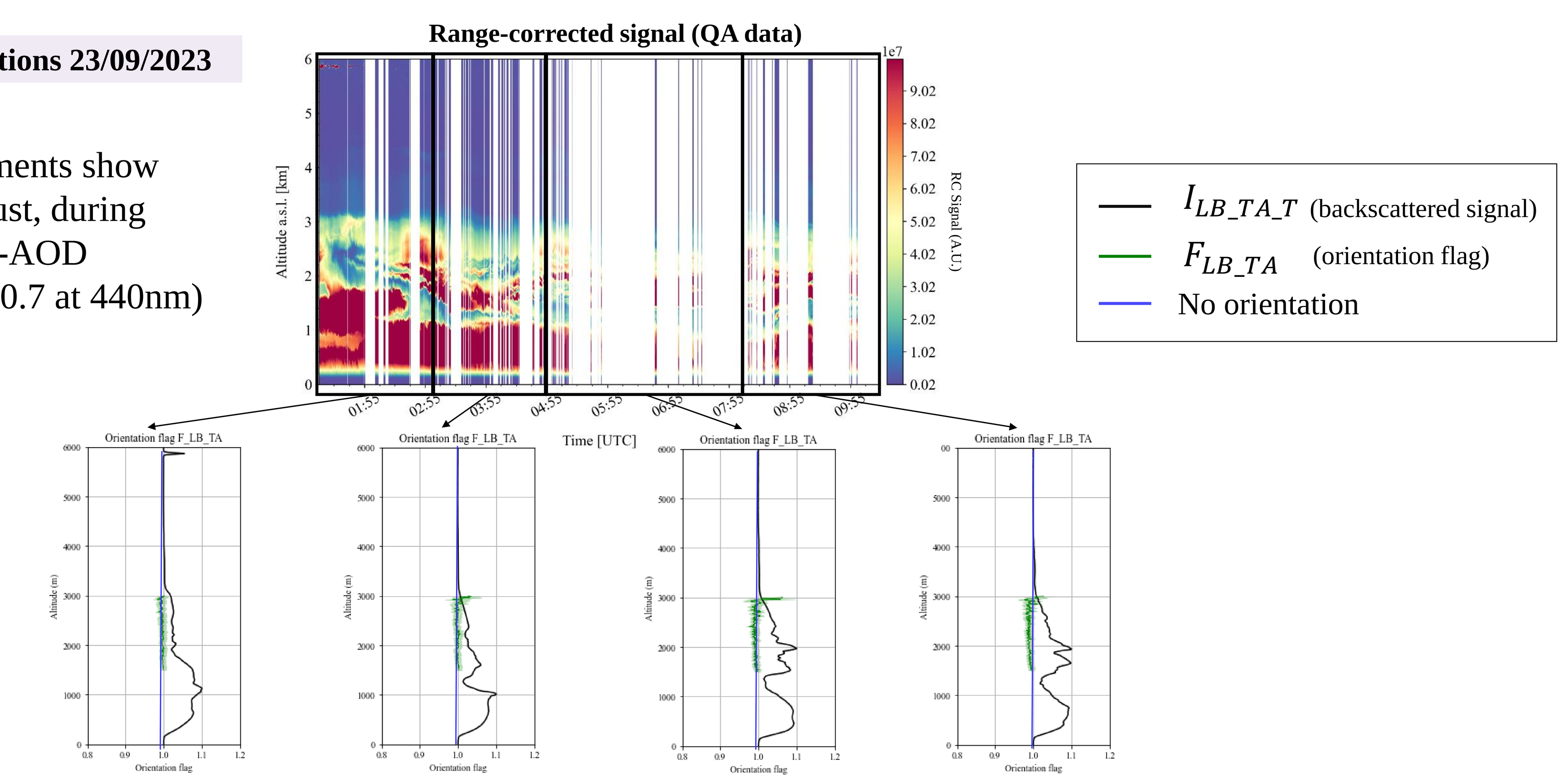
- Rain orientation (as expected)
- No orientation at high clouds (as expected in case of absent oriented ice crystals)
- No orientation of dust



Dust observations

WALL-E dust observations 23/09/2023

WALL-E measurements show no orientation of dust, during this relatively-high-AOD episode (AOD of ~0.7 at 440nm)



WALL-E dust observations 16-17/09/2023

WALL-E measurements show:

- Low dust orientation signals, associated though with high uncertainties
- No conclusive results for dust orientation