Assessing Aeolus Aerosol Observational Capabilities for Data Assimilation in Air Quality and NWP Models [ADD-CROSS]

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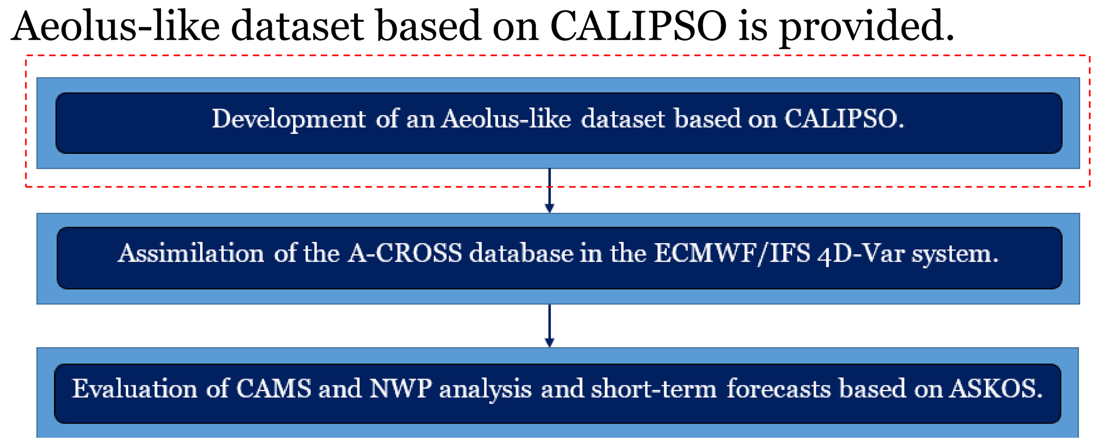
ADD-CROSS Challenge & Objectives

The Challenge:
The design of Aeolus-ALADIN enables the detection only of the returned co-polar component of the transmitted light.

The Objectives:
1. quantify the impact of the Aeolus missing cross-channel – total – on DA in air quality and NWP models.
2. quantify the impact of linear/circular configuration in the absence of the cross-polar channel.

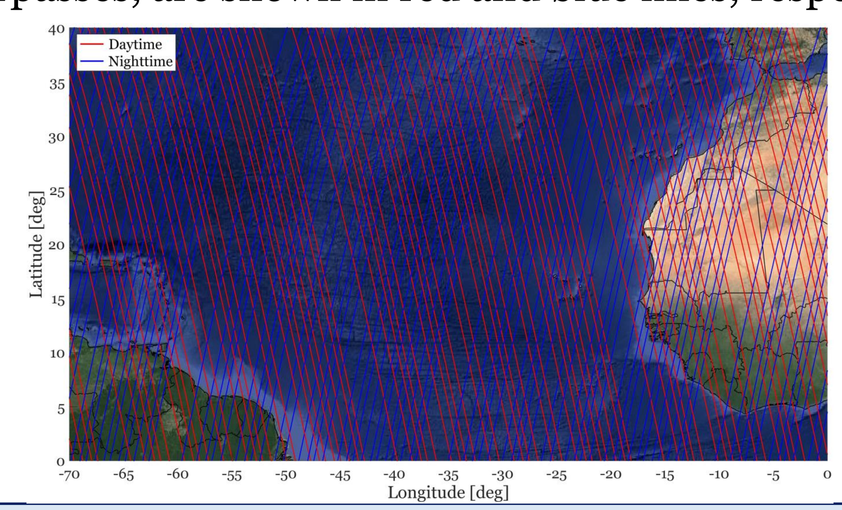
Conceptual Approach

The different experimental datasets (355nm - w/wo cross-channel / linear and circular) to be used in the ECWWF's 4D-Var, will be provided as a reconstruction of CALIPSO profiles of particulate depolarization ratio and backscatter coefficient in the mid-visible. Accordingly, the assimilation outputs will be extensively validated against reference ground-based measurements conducted in the framework of the ESA-JATAC-ASKOS campaign in Cabo-Verde on September 2021. Here, the establishment of the Aeolus-like dataset based on CALIPSO is provided.



Spatiotemporal Focus

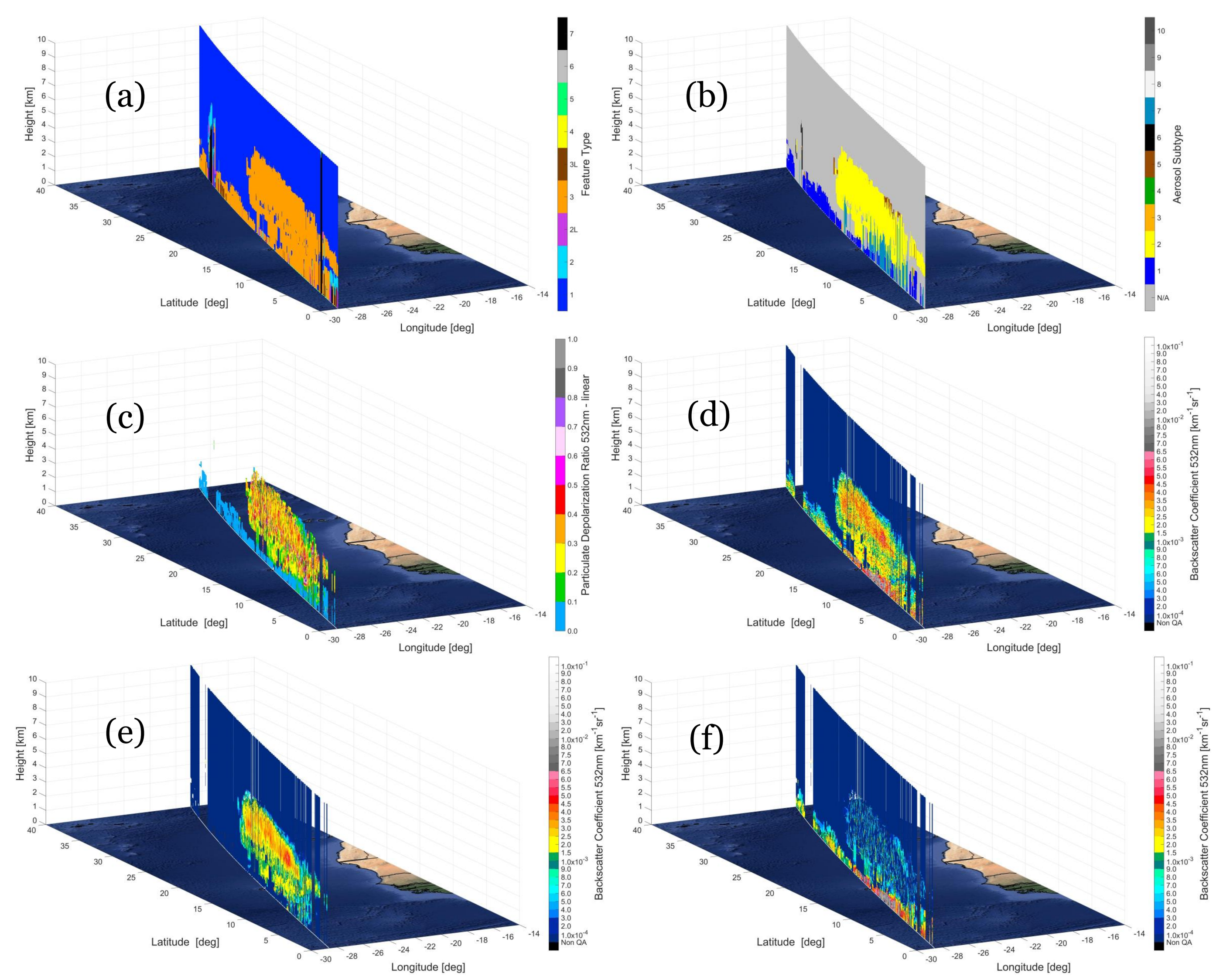
The Region of Interest (RoI) includes the Western Sahara and the Tropical Atlantic Ocean. The selection of RoI relies on the wealth of available observational datasets to-be-used for a complete and descriptive assessment analysis, thanks to the ESA JATAC-ASKOS Tropical Campaign conducted in Cabo Verde (September 2021). In the following figure, CALIPSO daytime and nighttime overpasses, are shown in red and blue lines, respectively.



Towards an Aeolus like dataset based on CALIPSO: Data & Methodology

Starting Point

The primary input datasets include CALIPSO CALIOP Version 4 (V4.21) Level 2 (L2) 5 km profiles of aerosol (APro) and clouds (CPro) [1]. The key datasets include particulate depolarization ratio and total backscatter coefficient at 532 nm. The processing methodology, as a first step applies several quality assurance (QA) procedures [2]. In addition, the ESA-LIVAS pure-dust product is utilized, towards decoupling the pure-dust and the non-dust components of the total backscatter coefficient at 532 nm profiles [3].



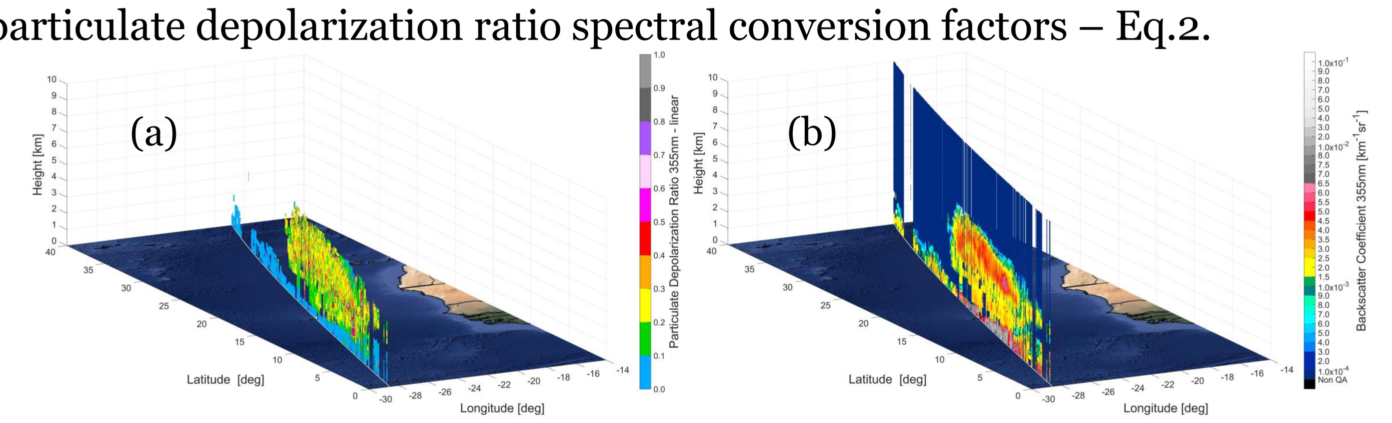
Aerosol Subtype (a), Feature Type (b), particulate depolarization ratio at 532 nm – linear (c), total backscatter coefficient at 532 nm including the (d) pure-dust (e) and non-dust (f) components, for the CALIPSO orbit "2021-09-05T04-02-05ZN".

Step-one

Total backscatter coefficient spectral conversion between 532 nm and 355 nm is provided according to the ESA-LIVAS [3] project, based on aerosol-subtype [4] dependent backscatter-related Ångström exponents established mainly based on EARLINET [5] – Eq.1. Particulate depolarization ratio 532-to-355 (linear) is established according to literature-based aerosol-subtype dependent particulate depolarization ratio spectral conversion factors – Eq.2.

$$\beta_{T,\lambda 2,aer.sub.} = \beta_{T,\lambda 1,aer.sub.} \left(\frac{\lambda_1}{\lambda_2}\right)^{BAE} \quad \text{(Eq.1)}$$

$$\delta_{lin,355nm}(z) = K_d * \delta_{lin,532nm}(z) \quad \text{(Eq.2)}$$



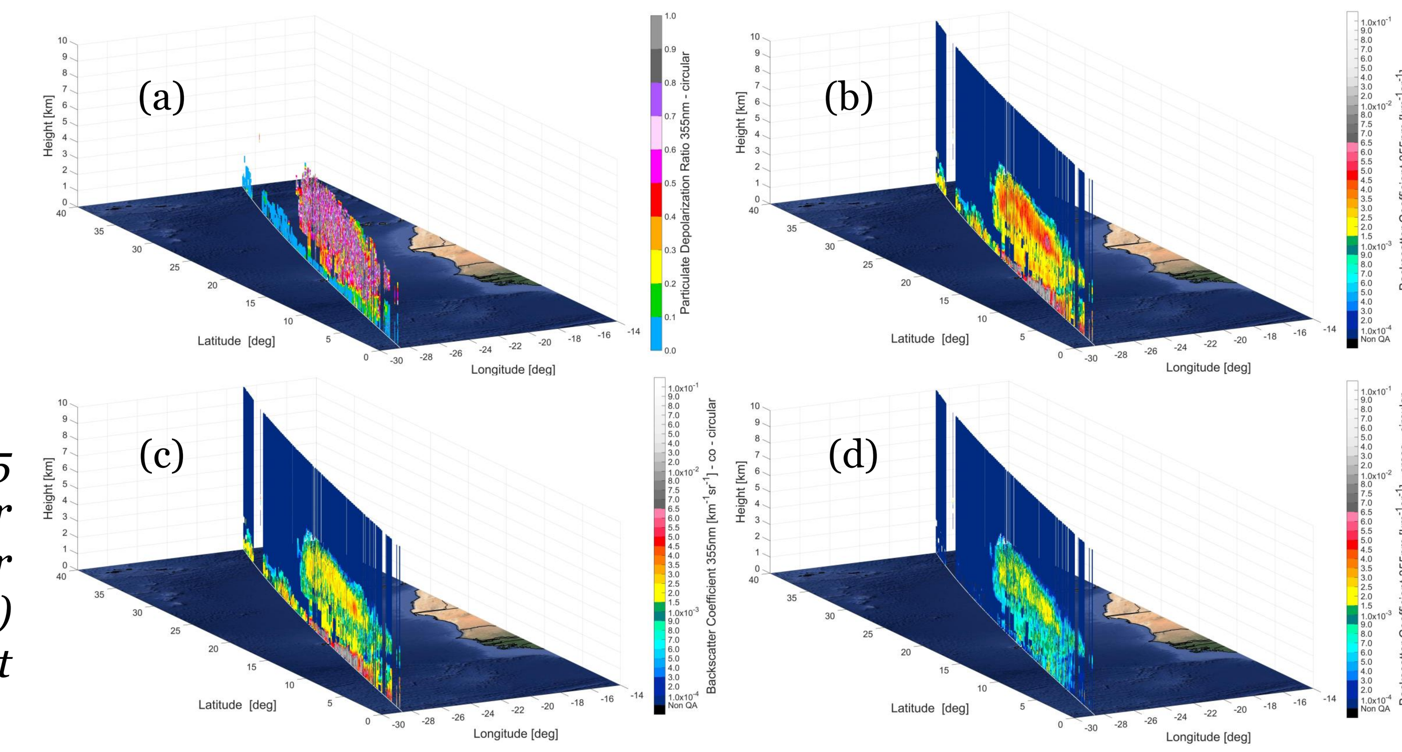
Particulate depolarization ratio at 355 nm – linear (a), and total backscatter coefficient at 355 nm (b) for the CALIPSO orbit "2021-09-05T04-02-05ZN".

Step-two

The linear depolarization ratio (δlin) and the circular depolarization ratio (δcir), in case of randomly oriented particles in the atmosphere and under single scattering assumption [6],[7] are related according to Eq.3. As a final step, the co-polar component is provided based on the total backscatter coefficient and the particulate depolarization ration - Eq.4.

$$\delta_{cir}(z) = \frac{2\delta_{lin}(z)}{1-\delta_{lin}(z)} \quad \text{(Eq.3)}$$

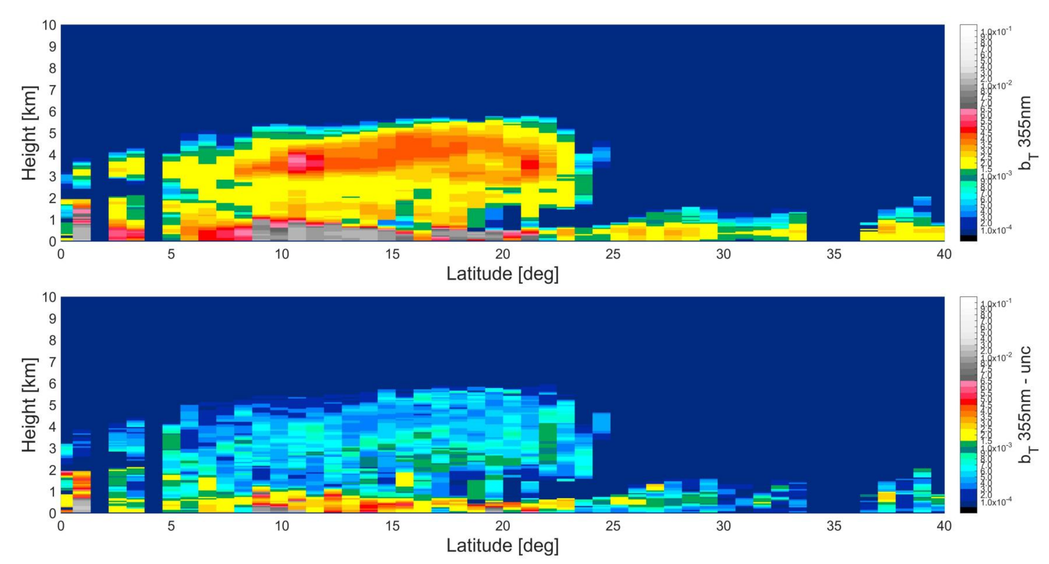
$$\beta_{\parallel,lin/cir}(z) = \frac{\beta_{T,lin/cir}(z)}{1+\delta_{lin/cir}(z)} \quad \text{(Eq.4)}$$



Particulate depolarization ratio at 355 nm – circular (a), total backscatter coefficient at 355 nm (b), backscatter coefficient co- (c), and cross- (d) components for the CALIPSO orbit "2021-09-05T04-02-05ZN".

Final-step and towards Data Assimilation – Future Steps

The final outcome CALIPSO-based Aeolus-like dataset, towards facilitating Data Assimilation, provides 355 nm - w/wo cross-channel circular products in Aeolus Basic Repeat Circle (BRC) horizontal resolution and with the original CALIPSO vertical resolution.



Backscatter Coefficient 355 nm – co – circular" (a) and "Backscatter Coefficient 355 nm – co – circular – unc" in Aeolus BRC horizontal resolution (b).

References

[1]Winker et al., 2010: Bull. Amer. Meteor. Soc., 91, 1211–1230, https://doi.org/10.1175/2010BAMS3009.1, [2]Tackett et al., 2018:, Atmos. Meas. Tech., 11, 4129–4152, https://doi.org/10.5194/amt-11-4129-2018. [3]Amiridis et al., 2015: Atmos. Chem. Phys., 15, 7127–7153, https://doi.org/10.5194/acp-15-7127-2015, [4]Kim et al.. 2018: Atmos Meas. Tech., 11, 6107–6135, https://doi.org/10.5194/amt-11-6107-2018, [5]Pappalardo et al., 2014: Atmos. Meas. Tech., 7, 2389–2409, https://doi.org/10.5194/amt-7-2389-2014, [6]Mishchenko, M. I., & Hovenier, J. W. (1995): Optics Letters, 20, 1356. https://doi.org/10.1364/OL.20.001356, [7]Roy, G., & Roy, N., 2008: Applied Optics. https://doi.org/10.1364/ao.47.006563.

Acknowledgement

The authors acknowledge support from the ADD-CROSS project activity.