Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP

Kick-Off

Virtual
08/11/2022
16:00-17:30 CEST

- *Agenda.*

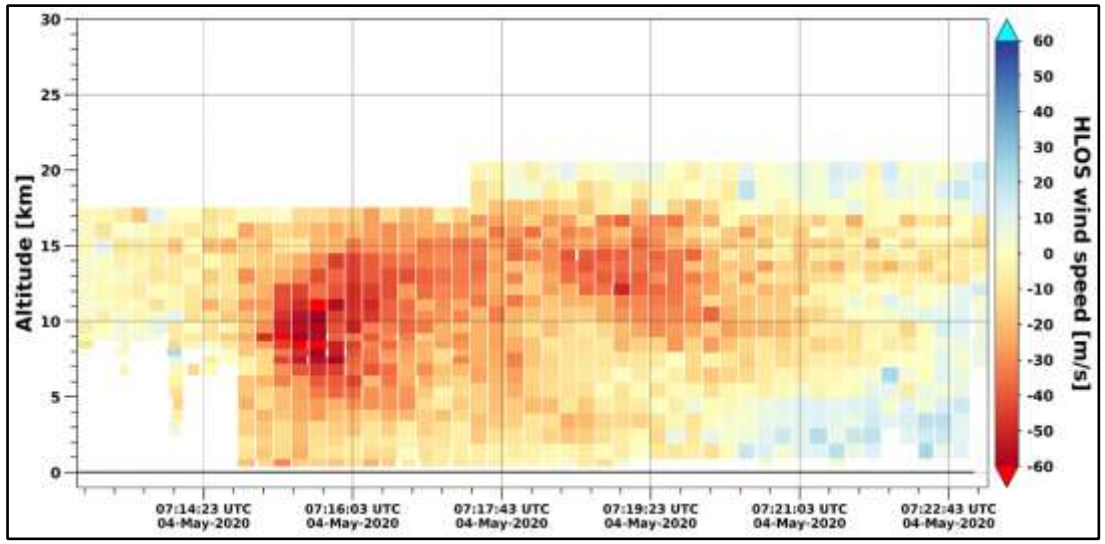
Time (CEST)	Title	*by…*
16:00 – 16:10	Introduction.	Christian Retscher (ESA) Vassilis Amiridis (NOA)
16:10 – 16:20	L2A+ Overview & WP1000.	Emmanouil Proestakis (NOA)
16:20 – 16:30	WP2000 - ASKOS ground-based datasets in support of L2A+.	Holger Baars (TROPOS)
16:30 – 16:40	WP3000 - Development of the L2A+ aerosol product.	Antonis Gkikas (NOA) Konstantinos Rizos (NOA)
16:40 – 16:50	WP4000 - Assimilation of L2A/L2A+ and application of WRF-L experiments.	Eleni Drakaki (NOA) Athanasios Georgiou (NOA)
16:50 – 17:00	WP5000 - Scientific Analysis and Impact Assessment.	Anna Kampouri (NOA) Emmanouil Proestakis (NOA).
17:00 – 17:05	WP6000 - Recommendations	Angela Benedetti (ECMWF).
17:05 – 17:30	Discussion.	

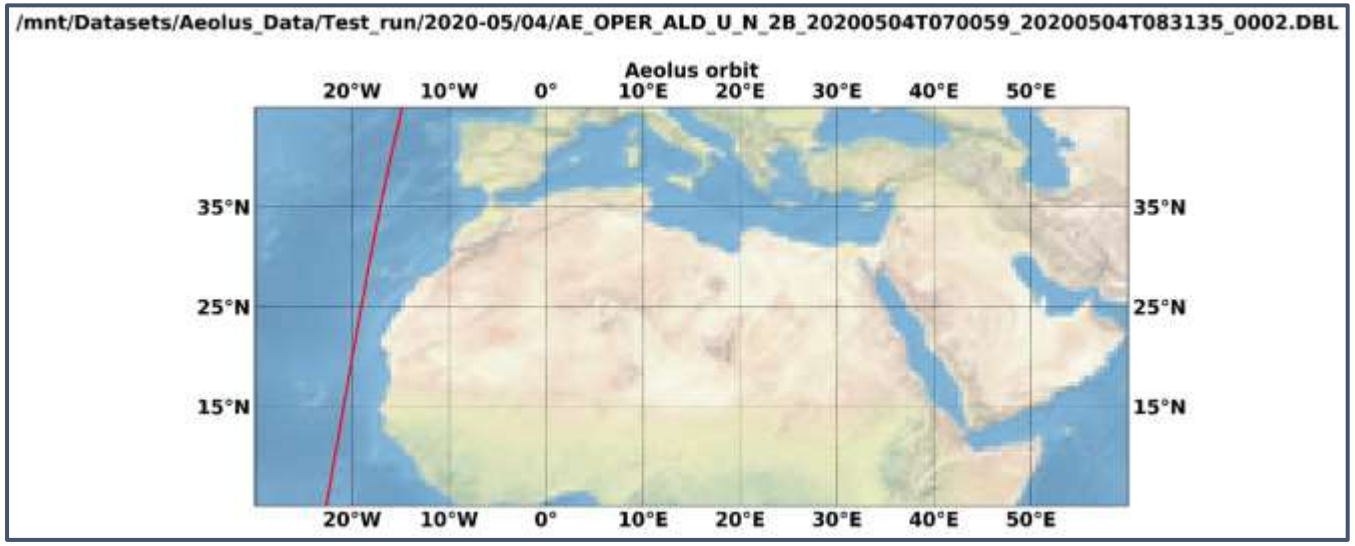
L2A+

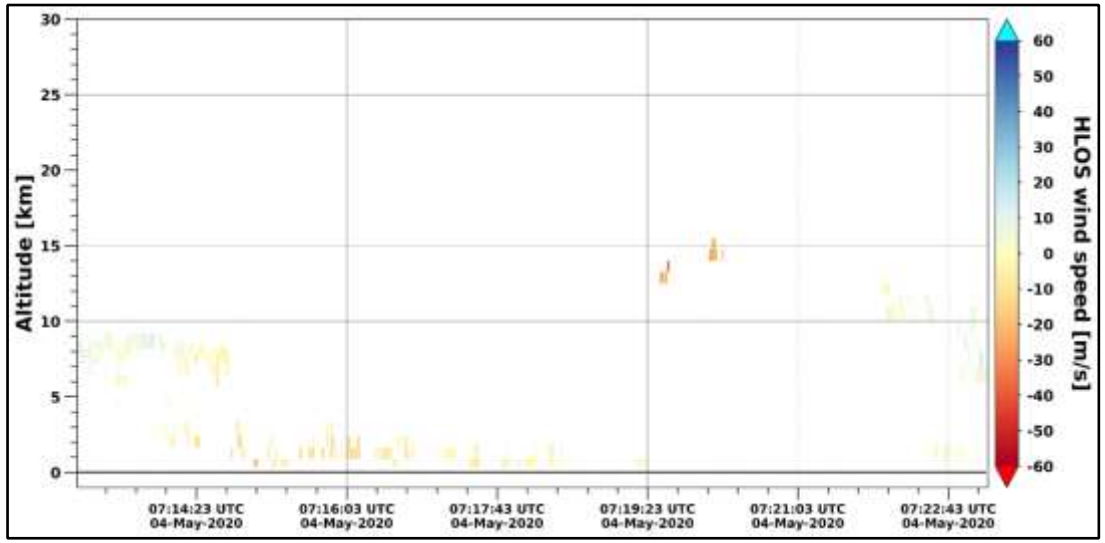
Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

- Background.

Aeolus, ESA's DWL – ALADIN – space mission provides:
- profiles of the HLOS wind component in the troposphere and the lower stratosphere.
- profiles of optical properties of aerosols and clouds (i.e., extinction/backscatter coefficients, lidar ratio).







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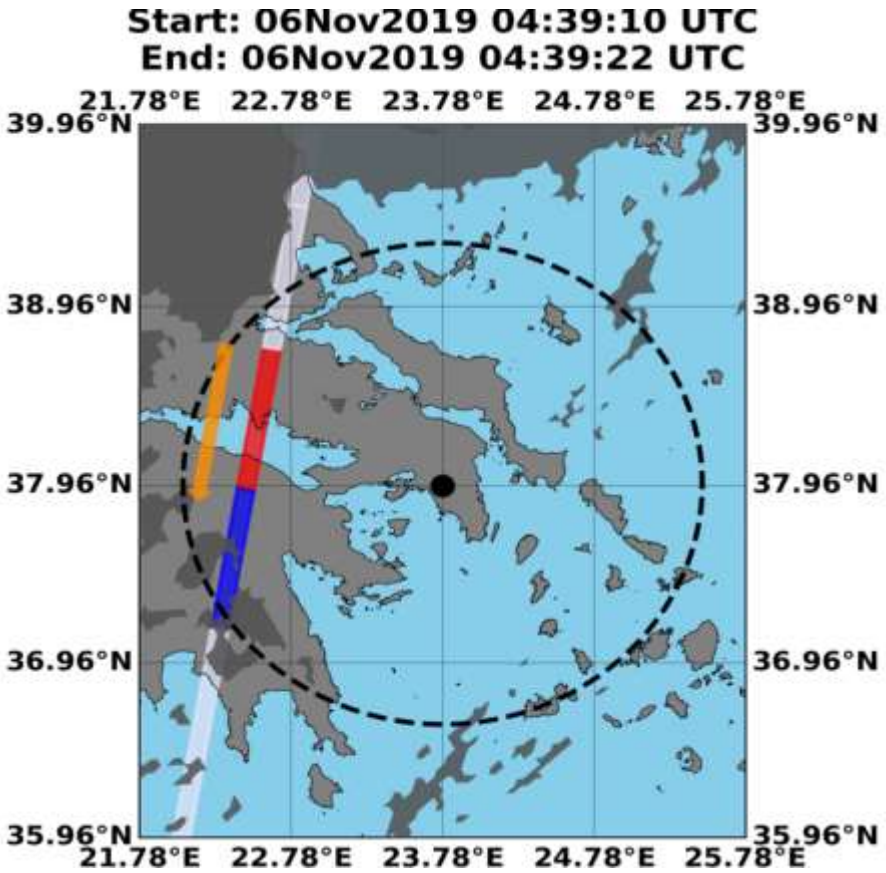
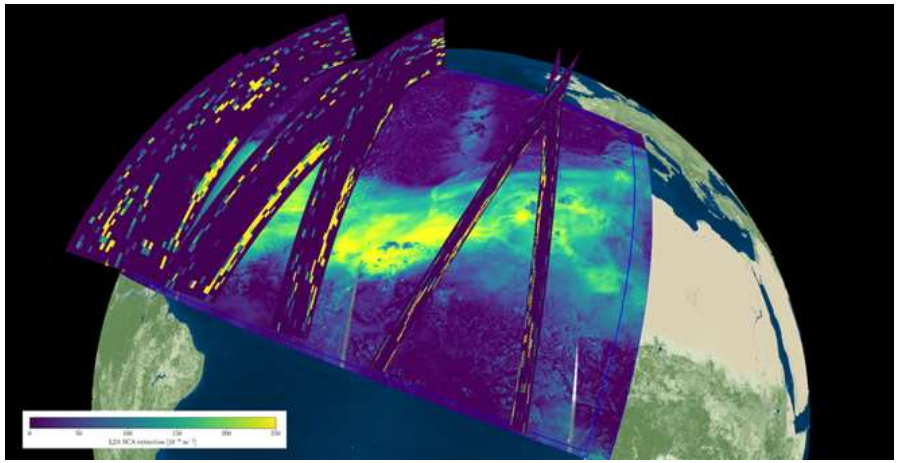
- Challenge (1): Cloud Contamination.

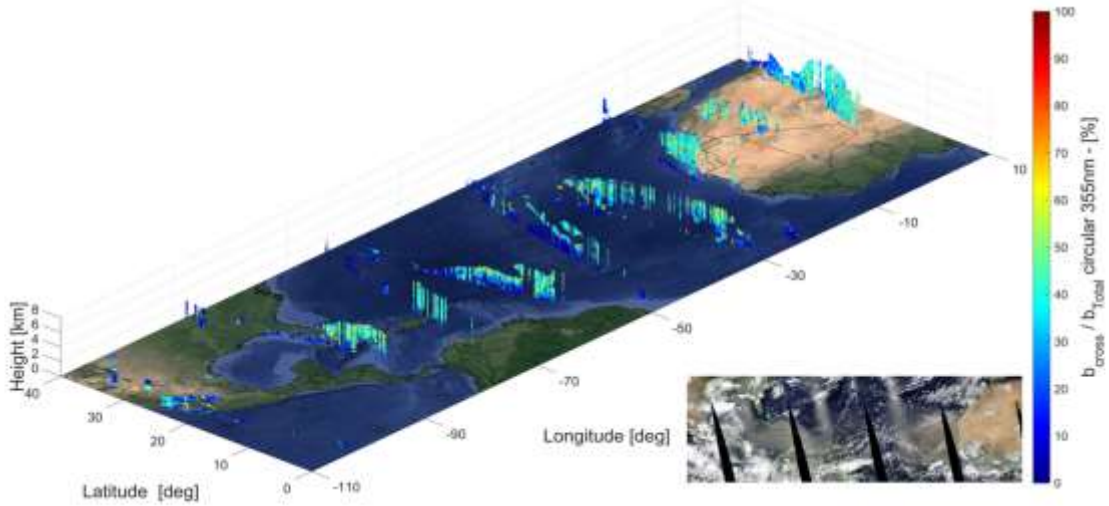


(Gkikas et al., 2022, ACPD)

- Challenge (2): Undetected cross polar backscattered component.



Retrieved from: esa.int



Estimates of Aeolus L2A underestimation due to the missing cross-channel using the Aeolus-like profiles retrieved based on CALIPSO for the transAtlantic Godzilla dust event on the 23rd of June, 2020.

L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

- Project Objectives.

Objective 1. **Develop a refined Aeolus aerosol optical product** (L2A+) over the **Atlantic,** based on AEL-FM/AEL-PRO algorithms, geostationary AOD products, CAMS, and new AOD retrievals from the Aeolus itself. The product will be thoroughly **compared with L2A** and **validated** against quality-assured measurements from the ASKOS/JATAC experiment in Cape Verde.

Objective 2. Examine the impact of L2A and L2A+ **on aerosol assimilation** and dust transport models.

Objective 3. Assess the **impact of Aeolus on NWP**, utilising L2A+ aerosol assimilation in an online coupled regional model driven by Aeolus wind-assimilated meteorological fields.

Objective 4. Highlight the benefit of the Aeolus joint aerosol and wind assimilation for **simulating dust deposition fields**, and compare with CAMS reanalysis to assess the impact of L2A+ for ocean biogeochemistry studies (working in parallel with the ESA-DOMOS study).

Objective 5. Compare the **monthly averaged L2A+** product with the **CALIPSO L3 product**, to assess the **climatological value of L2A+** for aerosol databases such as the **ESA-LIVAS long-term climate dataset**.

L2A+

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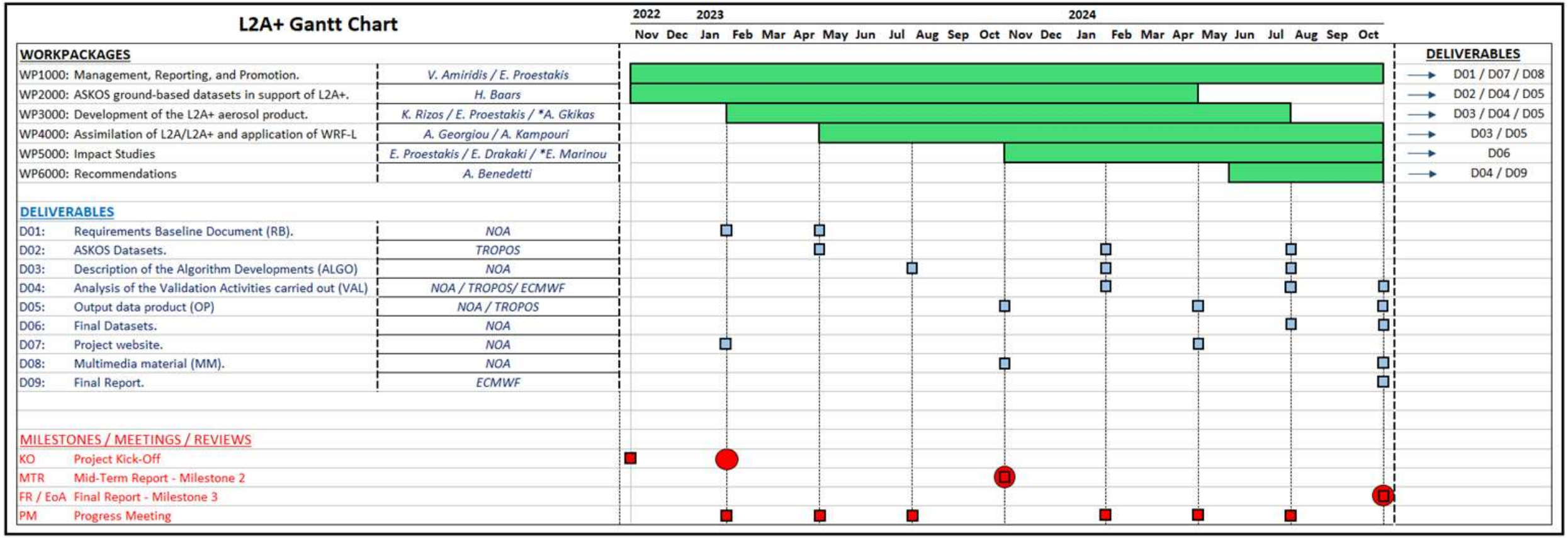
- *L2A+ Gantt Chart.*



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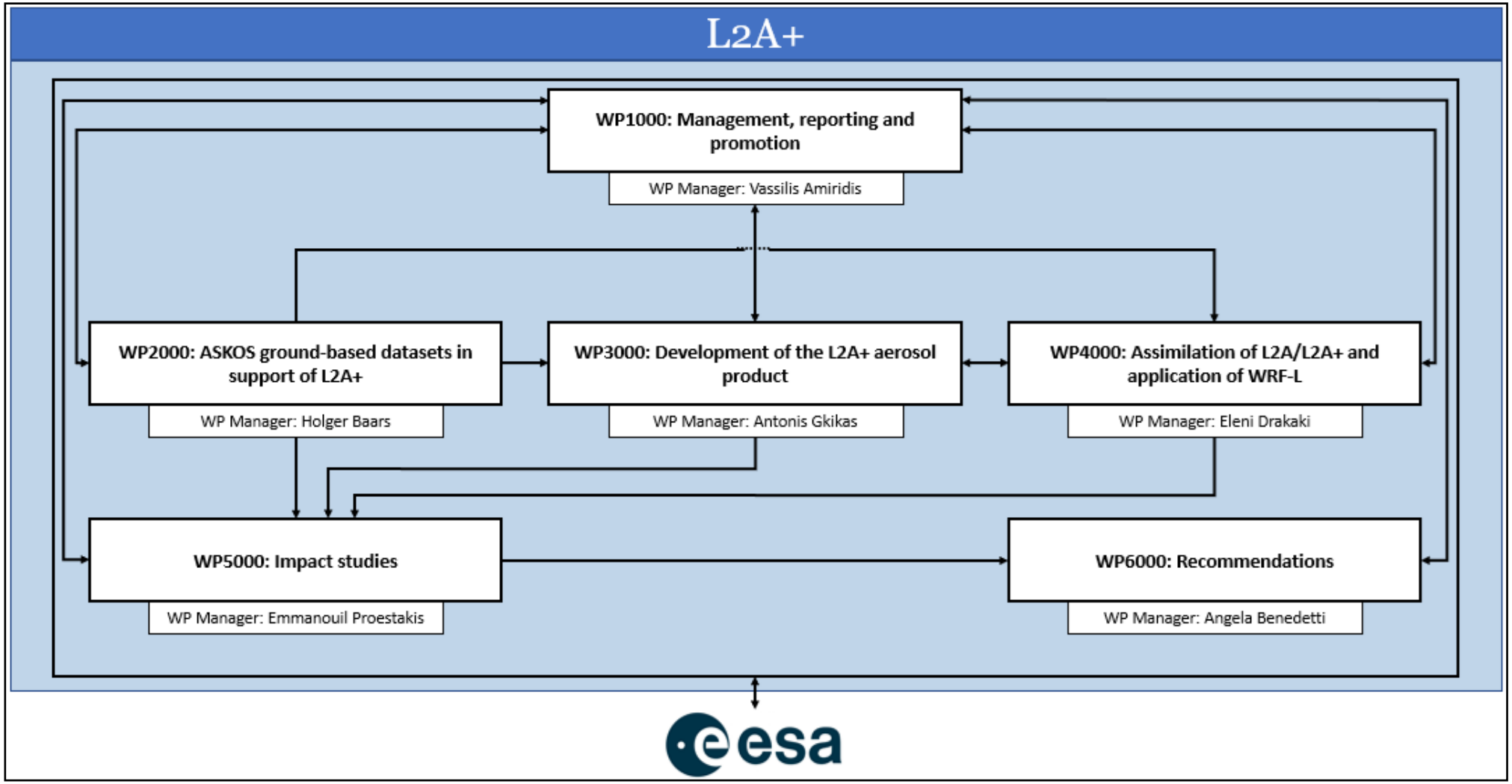
- *Work Breakdown Structure.*



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- *The L2A+ Team.*

WP1000

V. Amiridis

WP2000

H. Baars

A. Floutsi

WP3000

A. Gkikas

K. Rizos

WP6000

A. Benedetti

WP4000

A. Georgiou

A. Kampouri

E. Drakaki

A. Tsikerdekis

WP5000

E. Proestakis

A. Kampouri

E. Drakaki

D. Donovan

WP1000: *Management, reporting and promotion.*

Objective:	Monitoring of the L2A+ project, ensuring the timely and efficient accomplishment of the planned activities and administrative tasks and promotion of the project to the scientific community. Furthermore, WP1000 aims at consolidating the scientific requirements for L2A+ study.
Inputs:	All documents produced during the project.
Tasks:	Overall management and coordination of the project, in accordance with the terms of the signed contract.
Output:	• Building in and updating the project website. • Presenting the L2A+ results at scientific conferences and other international forums. • Publishing the work undertaken in peer-reviewed journals and conference proceedings. • DI01: Requirements Baseline Document (RB) • DI07: Project website including the compliance to the ESA Open Science catalogue server. • DI08: Multimedia material (MM) (Publications in peer-reviewed journals and conference proceedings, representation of the research at scientific conferences and other international forums through scientific presentations and exhibitions).

L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP2000: *ASKOS ground-based datasets in support of L2A+.*

Objective:	Provide ASKOS ground-based datasets for L2A+ product validation and model evaluation studies
Inputs:	Data acquired during ASKOS as part of the Joint Tropical Atlantic campaign (JATAC). All data has already been collected, but the analysis and exploitation has not yet been intensified or completed.
Tasks:	• Creation of a unique feature mask (Combined Cloudnet + EARLINET lidar target categorisation) • Application of the well-established Poliphon method to estimate the vertical resolved dust fraction • Application of an EarthCARE-like (HETEAC-Flex) typing scheme on the data from ground-based lidar in Mindelo to retrieve the volume concentration of mineral dust • Extraction of Aeolus-like profiles taken by the Aeolus reference instrument eVe •Use of the vertical wind information obtained with Doppler lidar and radar to estimate dust flux
Output:	•D2: Data set of feature mask over Mindelo for September 2021 including aerosol optical properties; Documentation on time series of profiles of wind speed over Mindelo and radiosonde profiles obtained at Sal. • D4: Analysis of Aeolus-like optical properties for Aeolus overpasses for validating/evaluating the new retrievals • D5: Final data set on the height-resolved dust-only profiles above Mindelo, Cabo Verde

L2A+

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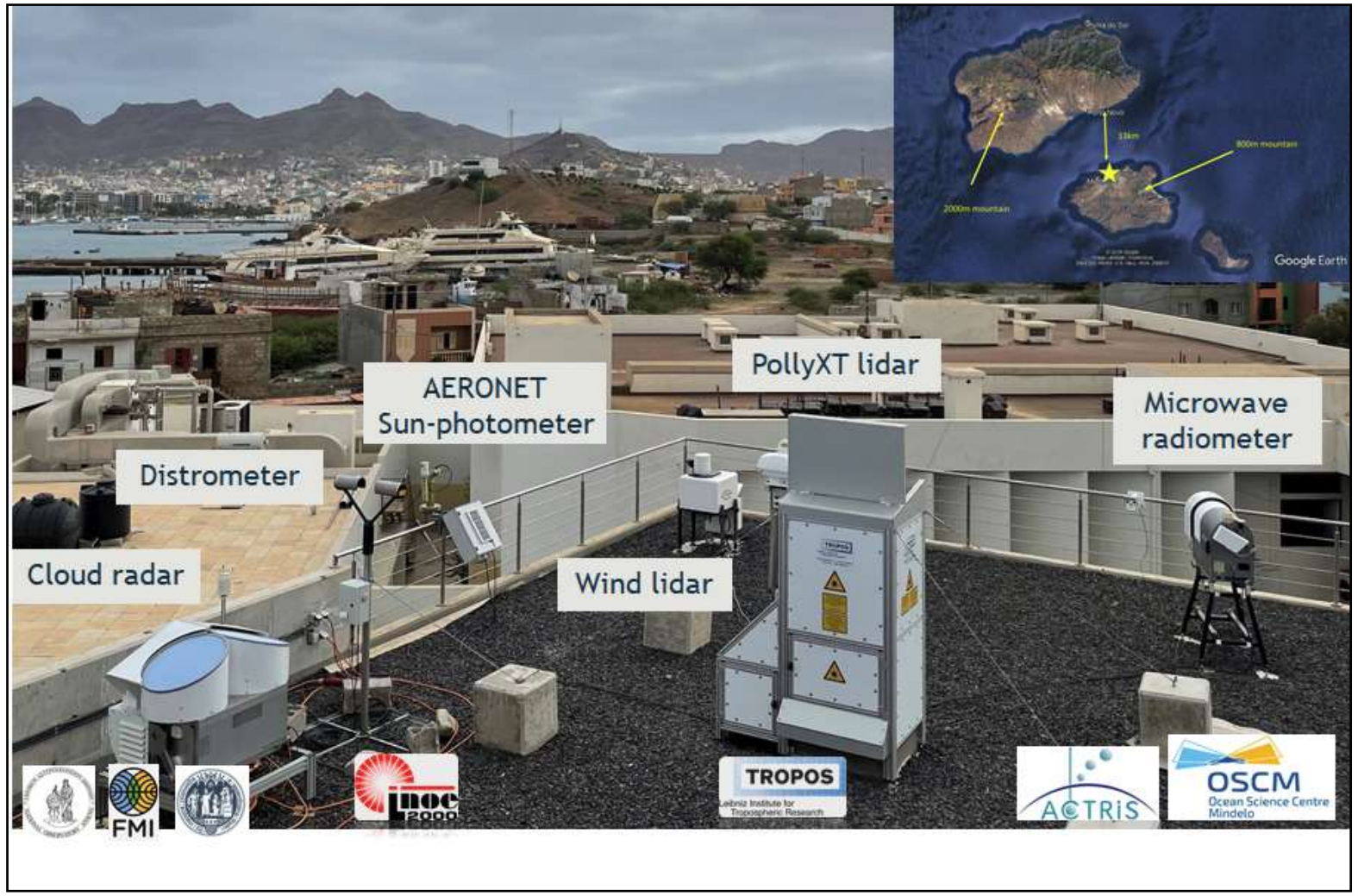
WP2000: *ASKOS ground-based datasets in support of L2A+.*

Instrumentation: Patchwork ACTRIS Aerosol & Cloud remote sensing facility



Instrumentation in September 2021

TROPOS instruments
- AERONET station (Cimel sun-photomoter)
- PollyXT lidar
- Wind lidar (Halo)
- Microwave radiometer (RPG)

ESA/INOE:
- 94Ghz Cloud radar (RPG)
- Distrometer

NOA:
- EVE reference lidar
  - can mimic Aeolus observations

- Polly.tropos.de (PollyXT quicklooks and products)
- Other quicklooks: askos.space.noa.gr

L2A+

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aeolus | ECMWF | TROPOS

WP2000:	*ASKOS ground-based datasets in support of L2A+.*

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PollyXT for Cabo Verde:

15 channel lidar for

3 backscatter coefficients
(355, 532 1064 nm)

3 extinction coeff.
(355, 532,1064 nm)

3 depolarization ratios
(355, 532, 1064 nm)

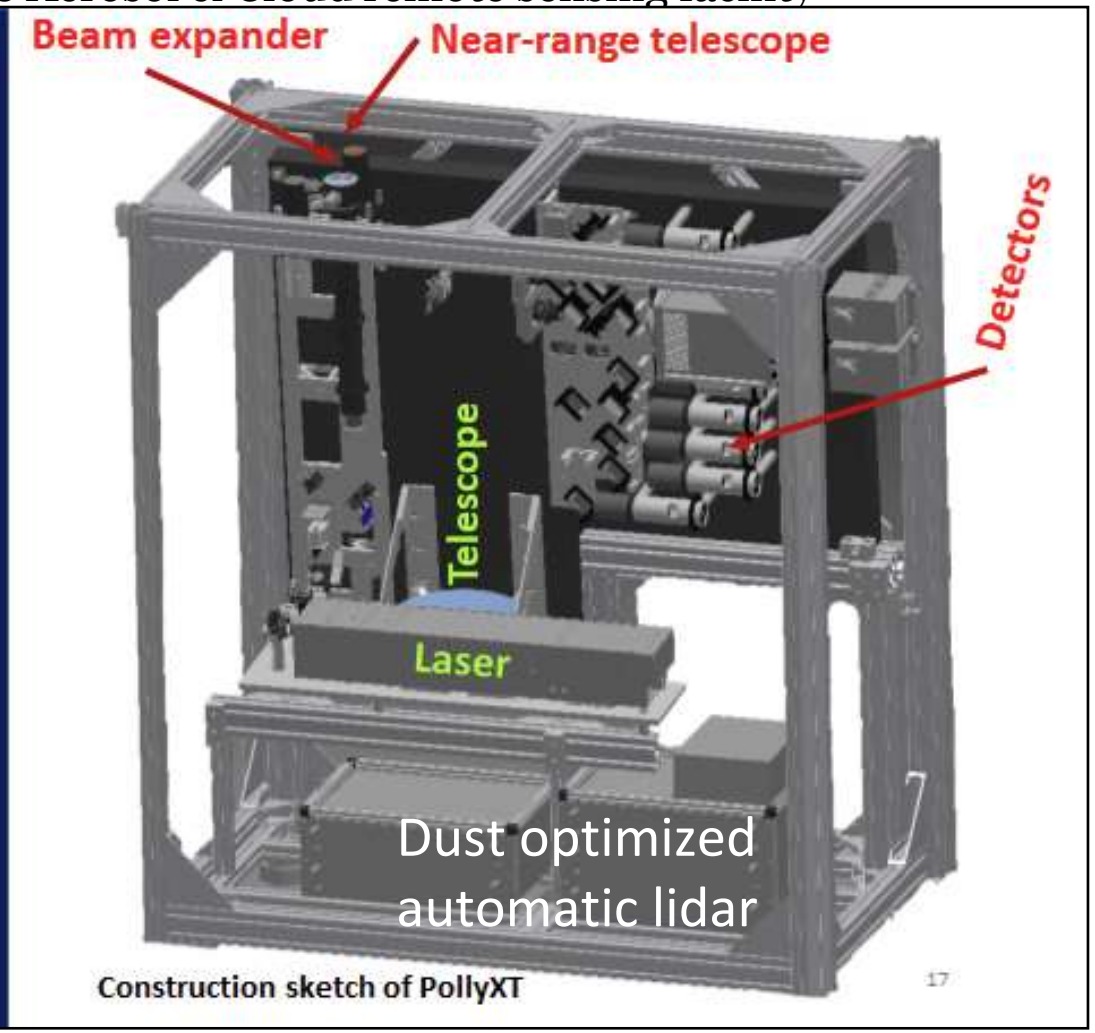
- Absolute depolarization calibration by ± 45° method
- "Cleaning" of laser polarization

Water vapor

Near range detector
(data from 100 m height)

Diode pumped laser (100 Hz)

Automatic data processing in PollyNET – NRT display:
polly.tropos.de



eVe - Aeolus reference lidar

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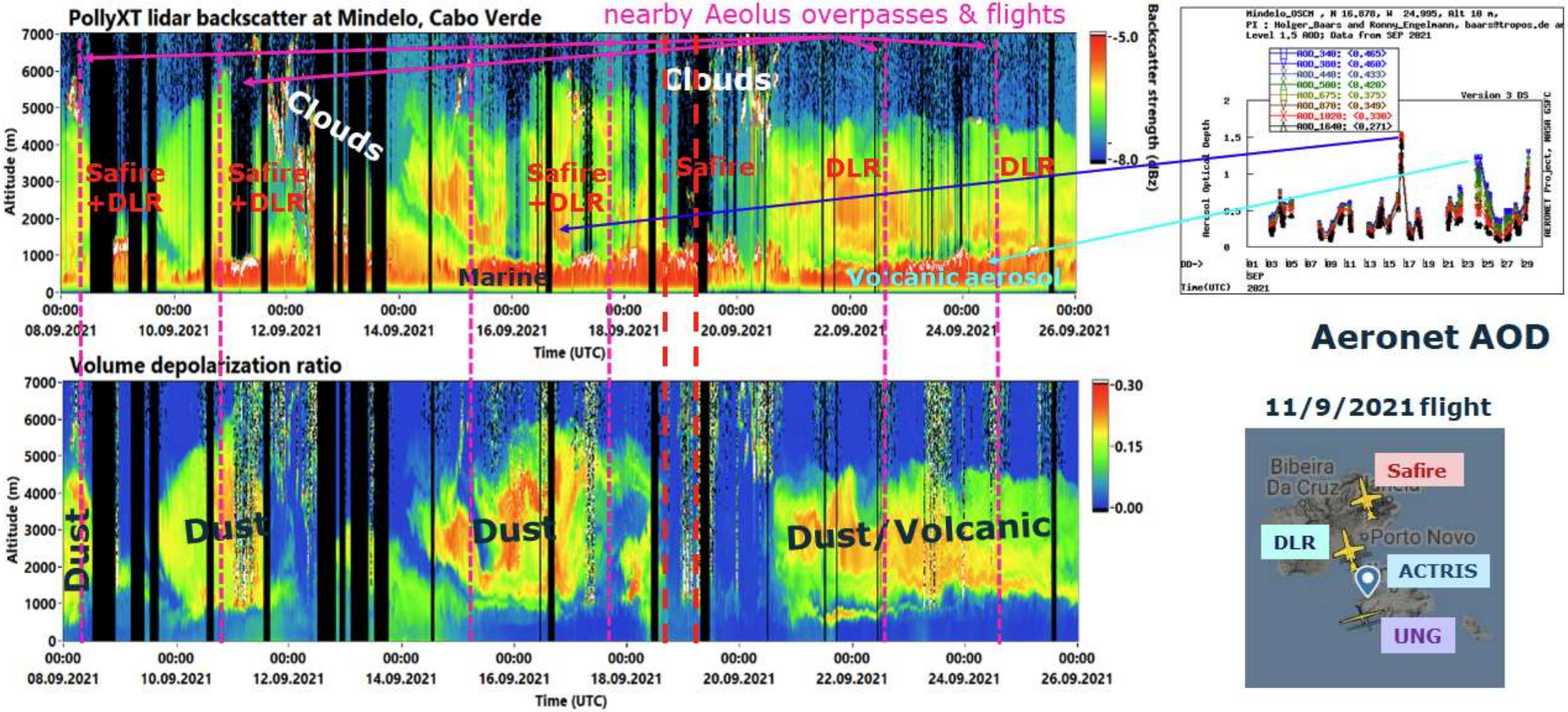
aeolus | ECMWF | TROPOS

WP2000: *ASKOS ground-based datasets in support of L2A+.*

Input data set:



Aeronet AOD

11/9/2021 flight

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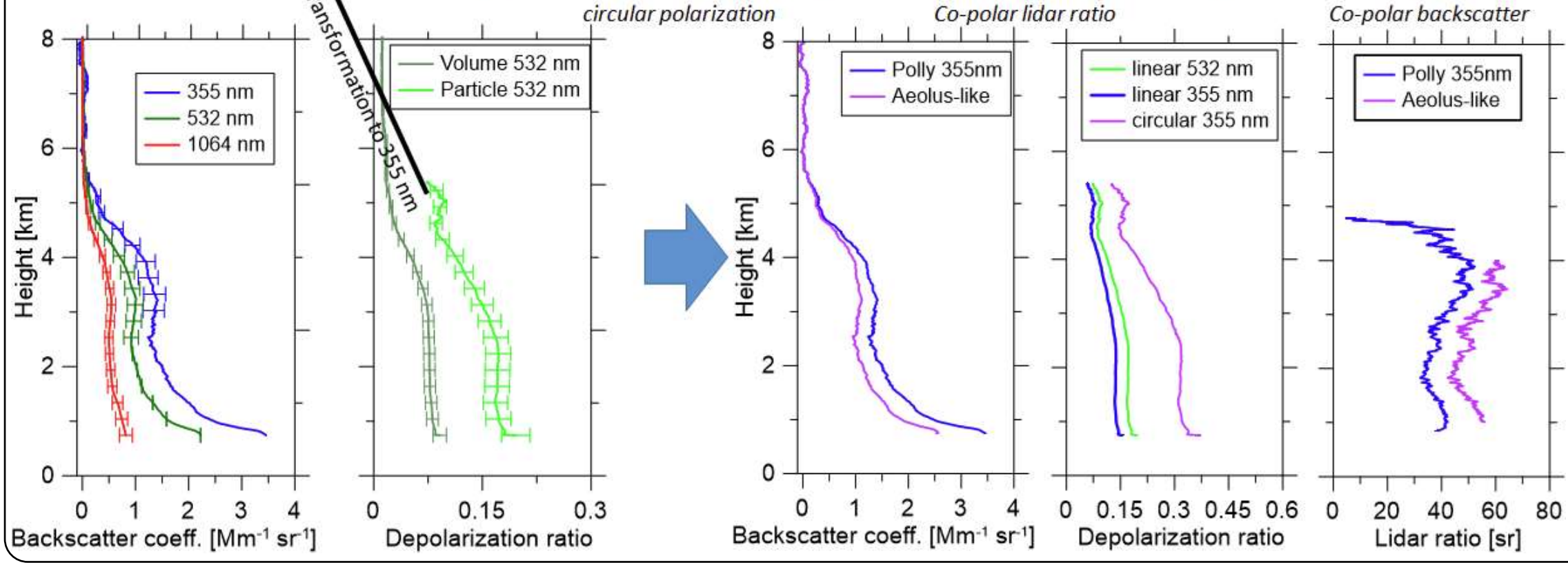
Transformation of Polly backscatter to Aeolus co-polar backscatter

$$\delta_{lin} = \frac{\beta^{cross}}{\beta^{co}} \Rightarrow \delta_{circ} = \frac{2\delta_{lin}}{1-\delta_{lin}} \Rightarrow S_{co} = S(\delta_{circ}+1) \Rightarrow \beta_{co} = \frac{\beta_{tot}}{(\delta_{circ}+1)}$$



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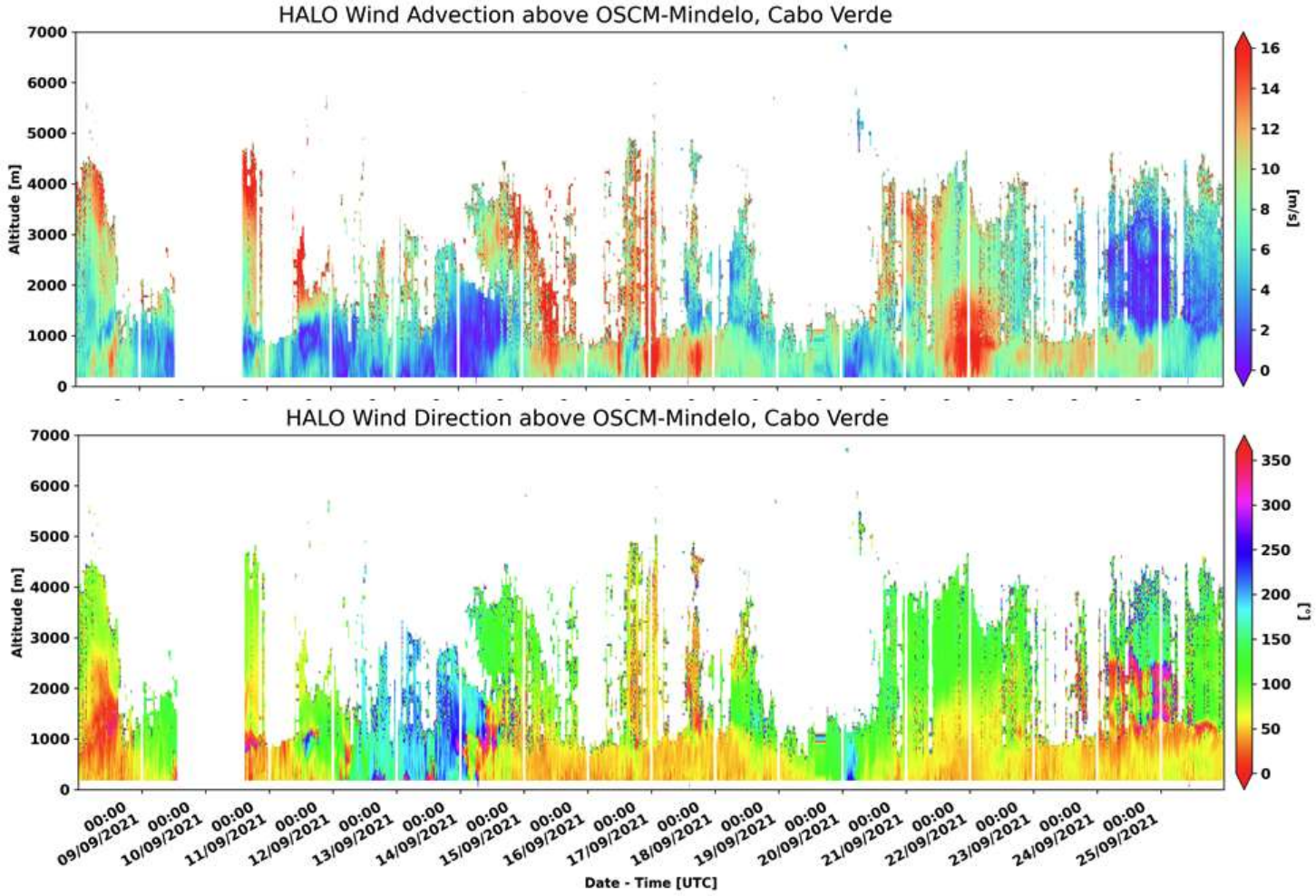
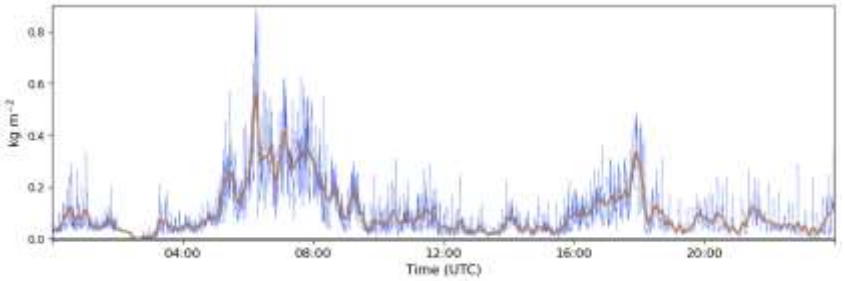
Input data set:



- Wind lidar:
  - Vertical wind speed
  - Horizontal wind speed and direction
- Microwave radiometer
  - Liquid water path



- Together with ESA / INOE cloud radar →Cloudnet target categorization
- By combining with PollyXT → **Advanced feature mask**

L2A+

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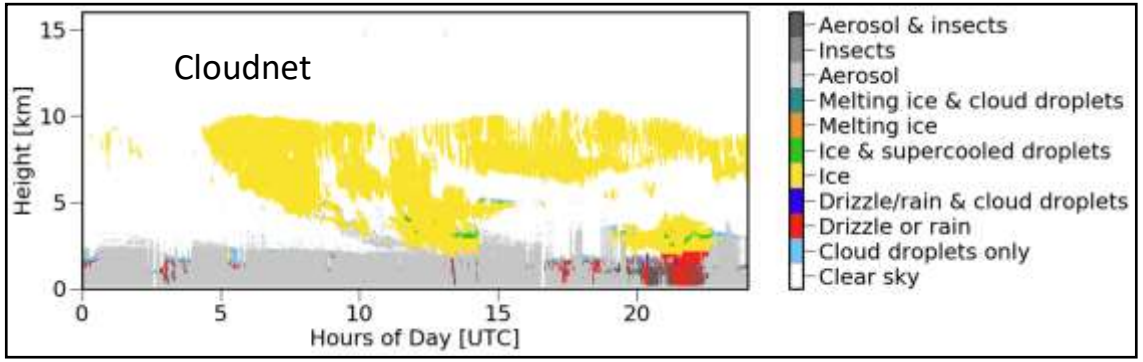
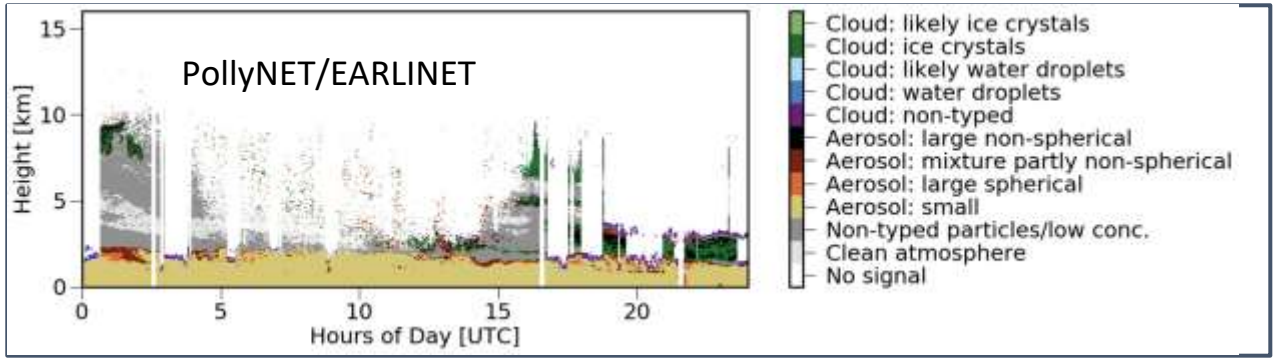
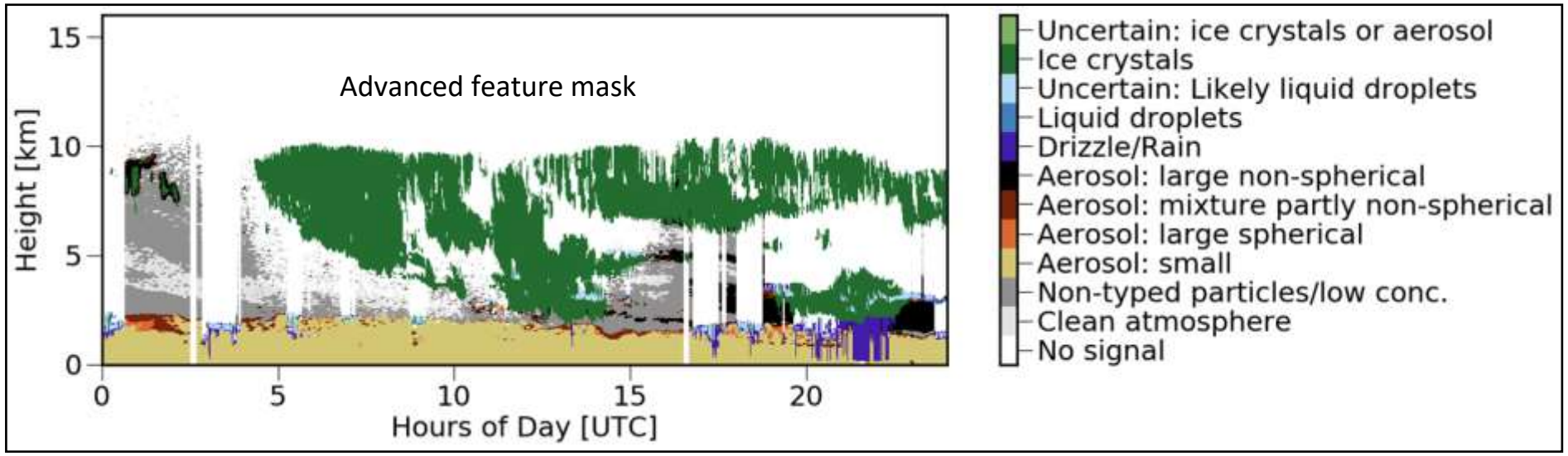
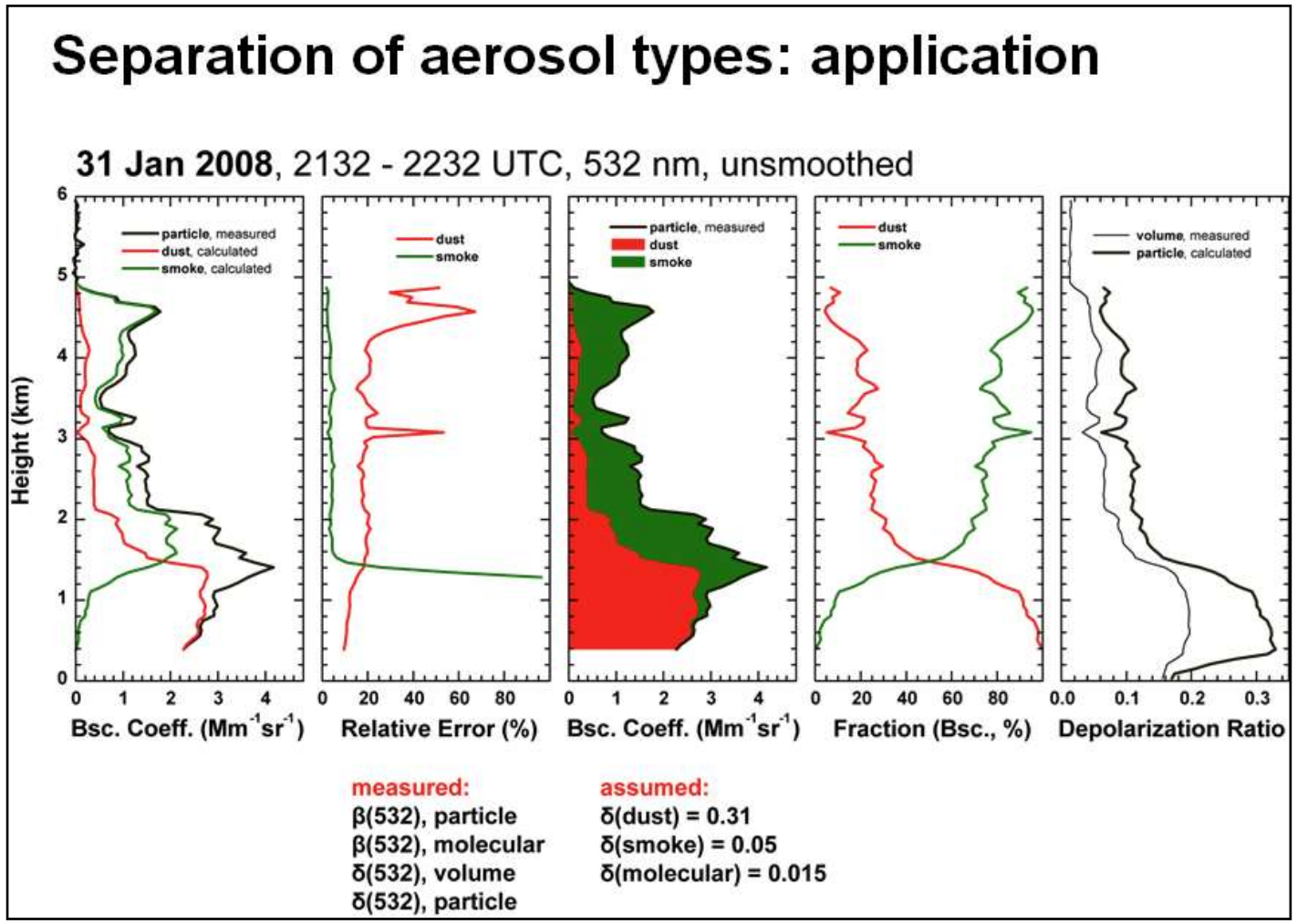
Example output data set for a Cyprus observation







Obtaining dust-only quantities



POLIPHON:
-Use of the depolarization ratio to calculate the dust fraction
- Obtaining dust-only backscatter
- Well established methodology

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, XXXXXX, doi:10.1029/2009JD011862, 2009

Click Here for Full Article

Vertically resolved separation of dust and smoke over Cape Verde using multiwavelength Raman and polarization lidars during Saharan Mineral Dust Experiment 2008

M. Tesche,[1] A. Ansmann,[1] D. Müller,[1] D. Althausen,[1] R. Engelmann,[1] V. Freudenthaler,[2] and S. Groß[2]

Received 6 February 2009; revised 14 April 2009; accepted 20 April 2009; published XX Month 2009.

L2A+

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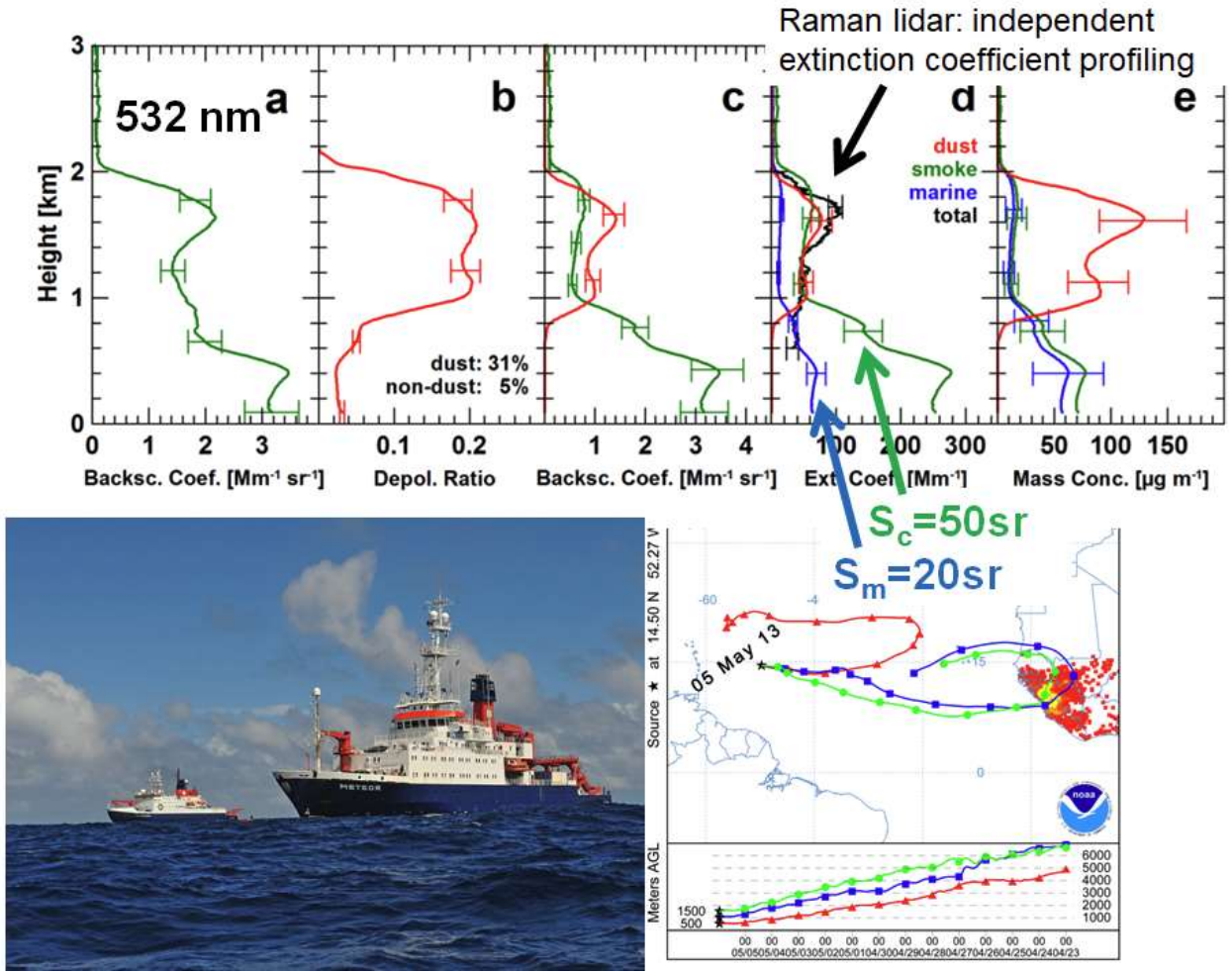
Obtaining dust-only quantities



POLIPHON:
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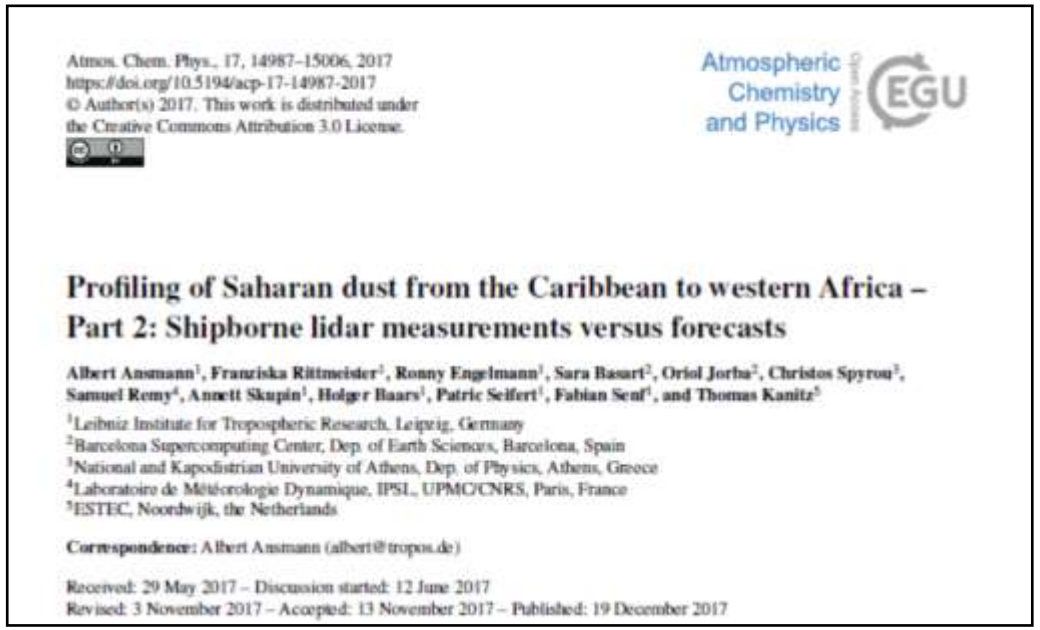

Atmos. Chem. Phys., 17, 14987–15006, 2017
https://doi.org/10.5194/acp-17-14987-2017
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Atmospheric Chemistry and Physics

Profiling of Saharan dust from the Caribbean to western Africa – Part 2: Shipborne lidar measurements versus forecasts

Albert Ansmann[1], Franziska Rittmeister[1], Ronny Engelmann[1], Sara Basart[2], Oriol Jorba[2], Christos Spyrou[3], Samuel Remy[4], Annett Skupin[1], Holger Baars[1], Patric Seifert[1], Fabian Senf[1], and Thomas Kanitz[5]

[1]Leibniz Institute for Tropospheric Research, Leipzig, Germany
[2]Barcelona Supercomputing Center, Dep. of Earth Sciences, Barcelona, Spain
[3]National and Kapodistrian University of Athens, Dep. of Physics, Athens, Greece
[4]Laboratoire de Météorologie Dynamique, IPSL, UPMC/CNRS, Paris, France
[5]ESTEC, Noordwijk, the Netherlands

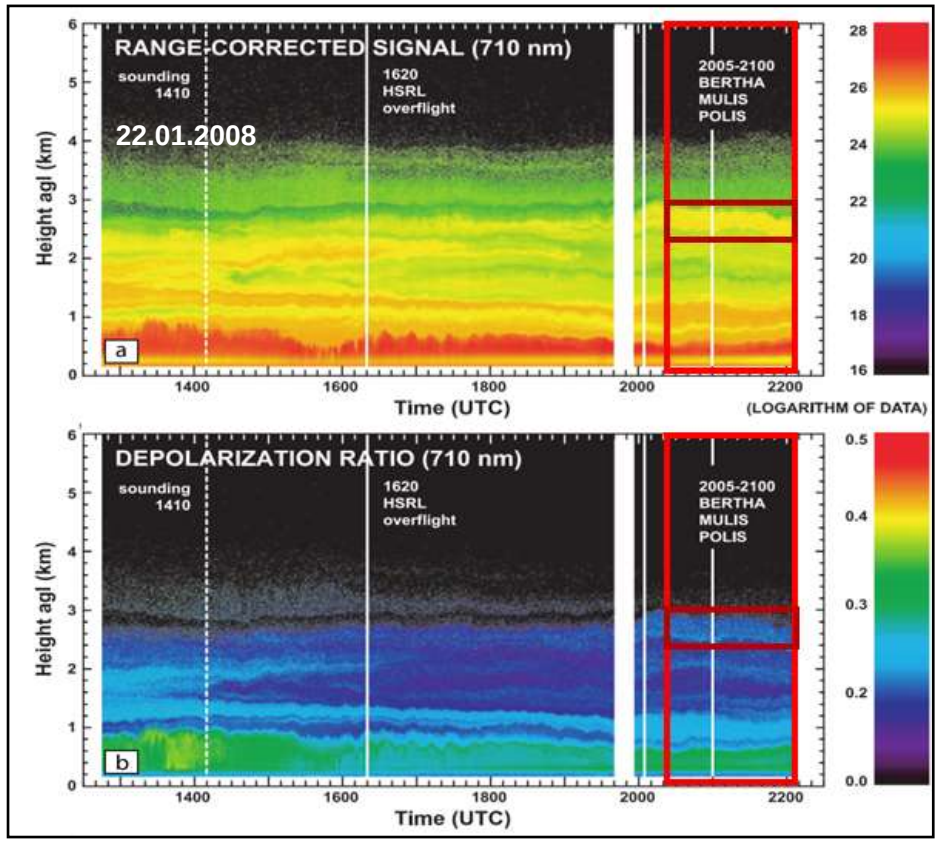
Correspondence: Albert Ansmann (albert@tropos.de)

Received: 29 May 2017 – Discussion started: 12 June 2017
Revised: 3 November 2017 – Accepted: 13 November 2017 – Published: 19 December 2017

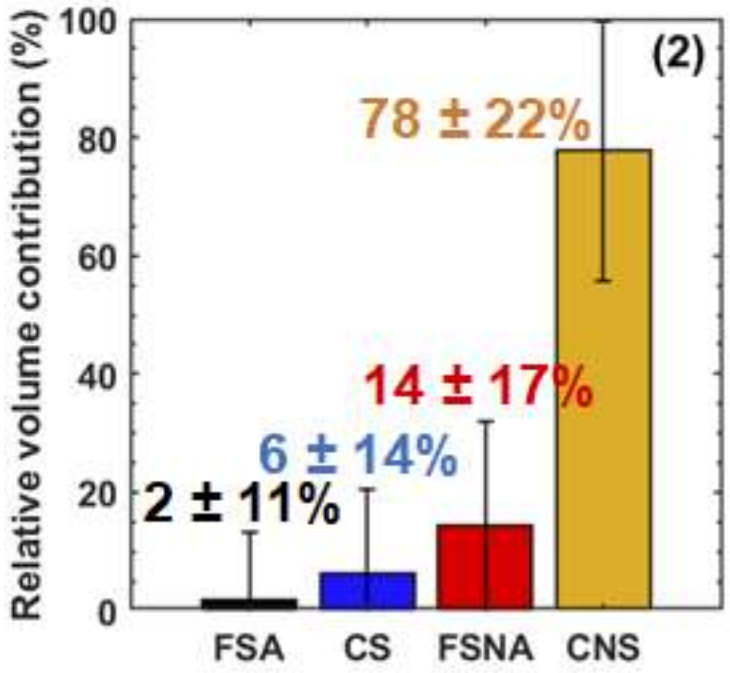
Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

ASKOS ground-based datasets in support of L2A+.

From POLIPHON to HETEAC-Flex - the EarthCARE-like typing scheme



HETEAC-Flex



- Fine Spherical Absorbing
- Coarse Spherical
- Fine Spherical Non- Absorbing
- Coarse Non-Spherical

Backscatter and extinction per aerosol component (532 nm)

Consistent with POLIPHON but the non-dust fraction can be better typed

L2A+

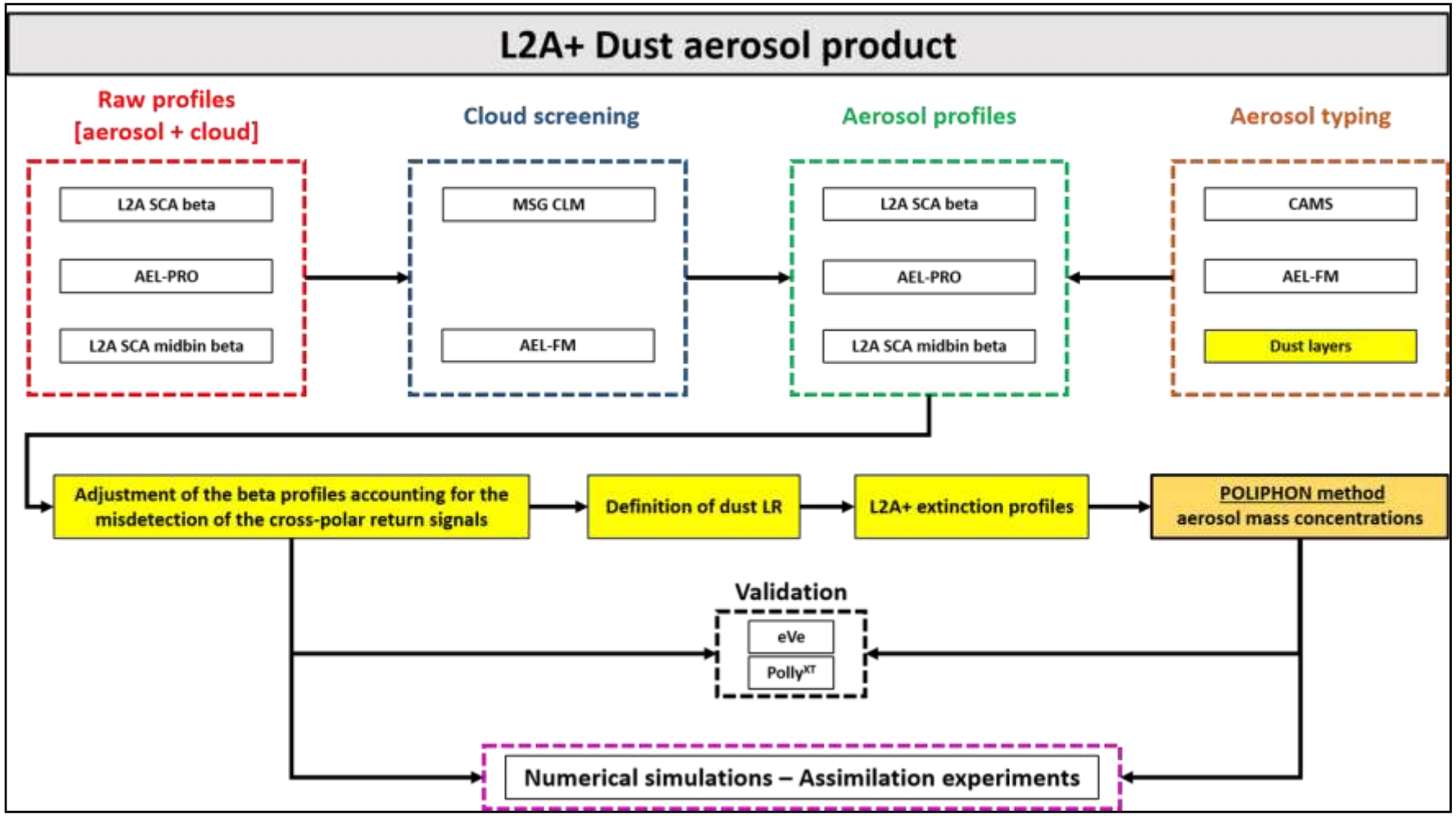
Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP3000: *Development of the L2A+ aerosol product.*

Objective:	**Derivation of the L2A+ extinction and aerosol mass concentration product**
Inputs:	Aeolus L2A profiles, AEL-FM/PRO, SEVIRI CLAAS-3 cloud dataset, CAMS
Tasks:	1. **Implementation of a rigorous screening of cloud contaminated Aeolus profiles** via the synergy of AEL-FM retrievals and MSG geostationary cloud imagery 2. **Exploitation of CAMS vertically resolved aerosol typing** for identifying the vertical extension of dust layers within the RoI 3. **Reconstruction of Aeolus cloud-free dust extinction profiles** by adjusting the absent cross-polar backscatter and defining suitable dust lidar ratio(s) 4. **Assessment analysis of Aeolus L2A+ aerosol profiles**
Output:	• D3: Description of the Algorithm Developments (ALGO) • D4: Analysis of the Validation Activities carried out (VAL) • D5: Output data product (OP)

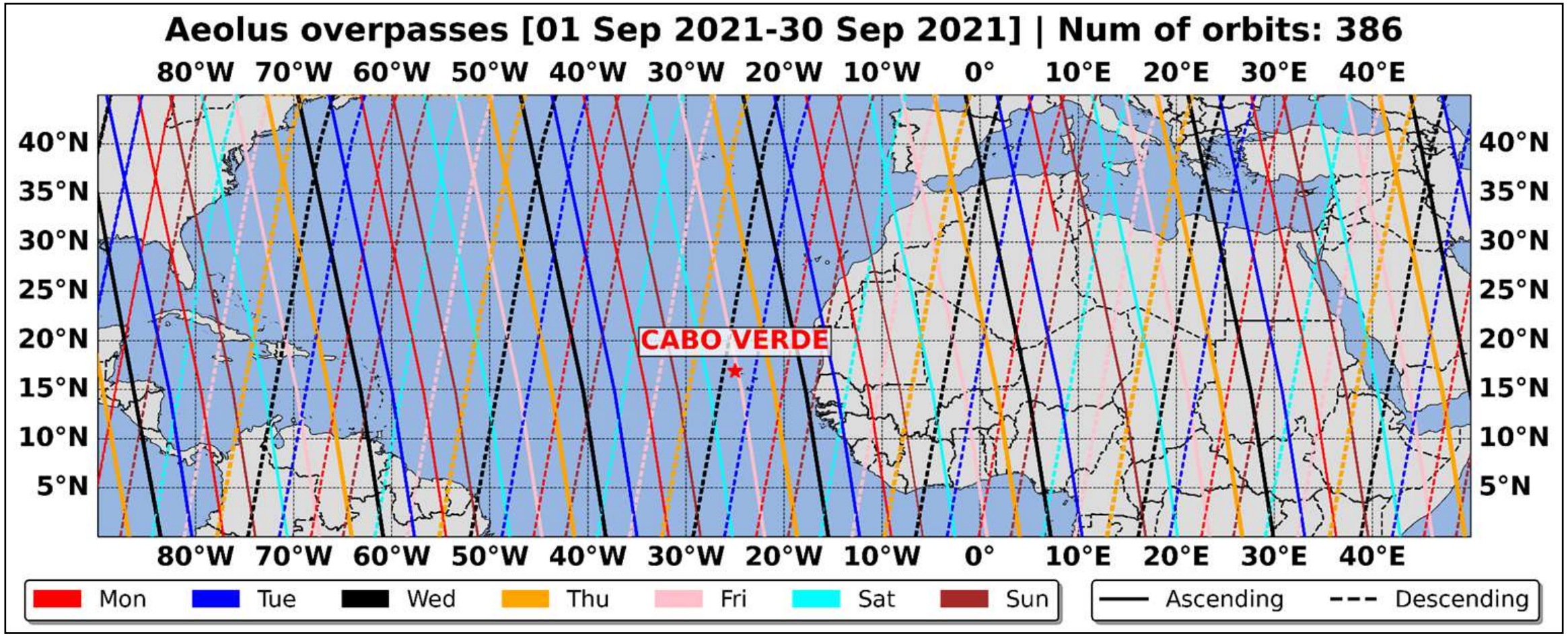
WP3000: *Development of the L2A+ aerosol product.*

Workflow of the WP3000 activities



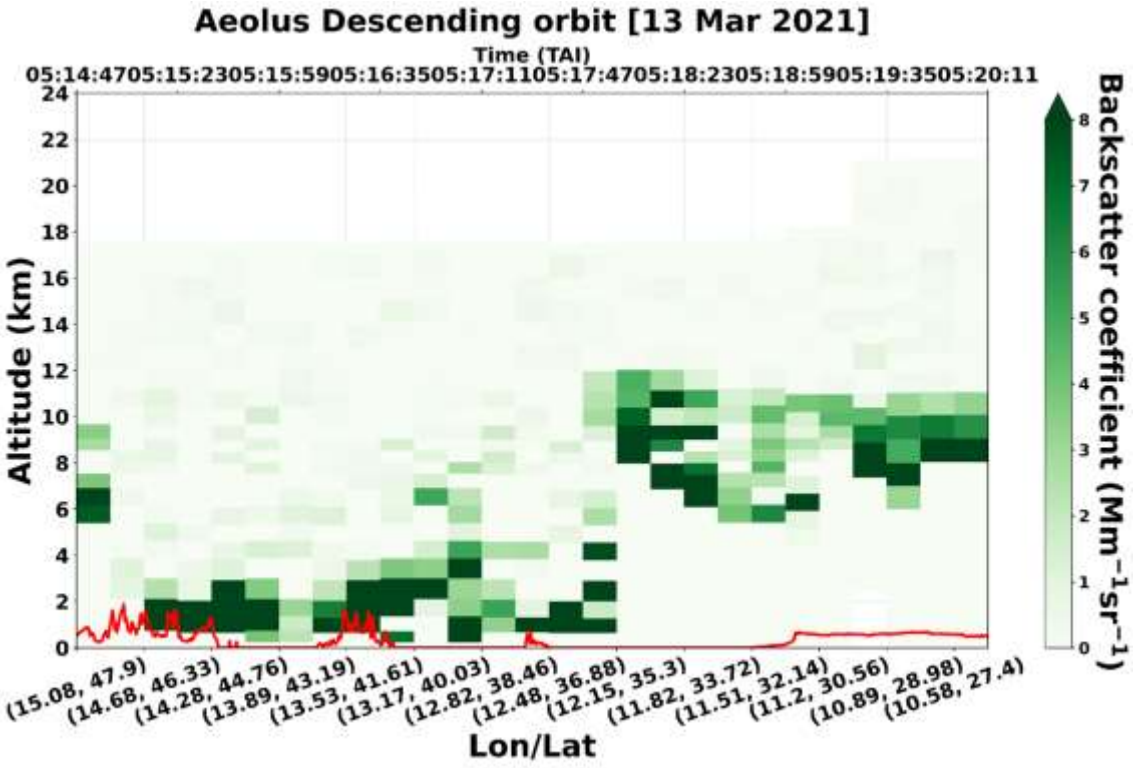
WP3000: *Development of the L2A+ aerosol product.*

Aeolus overpasses within the RoI over the study period (September 2021)

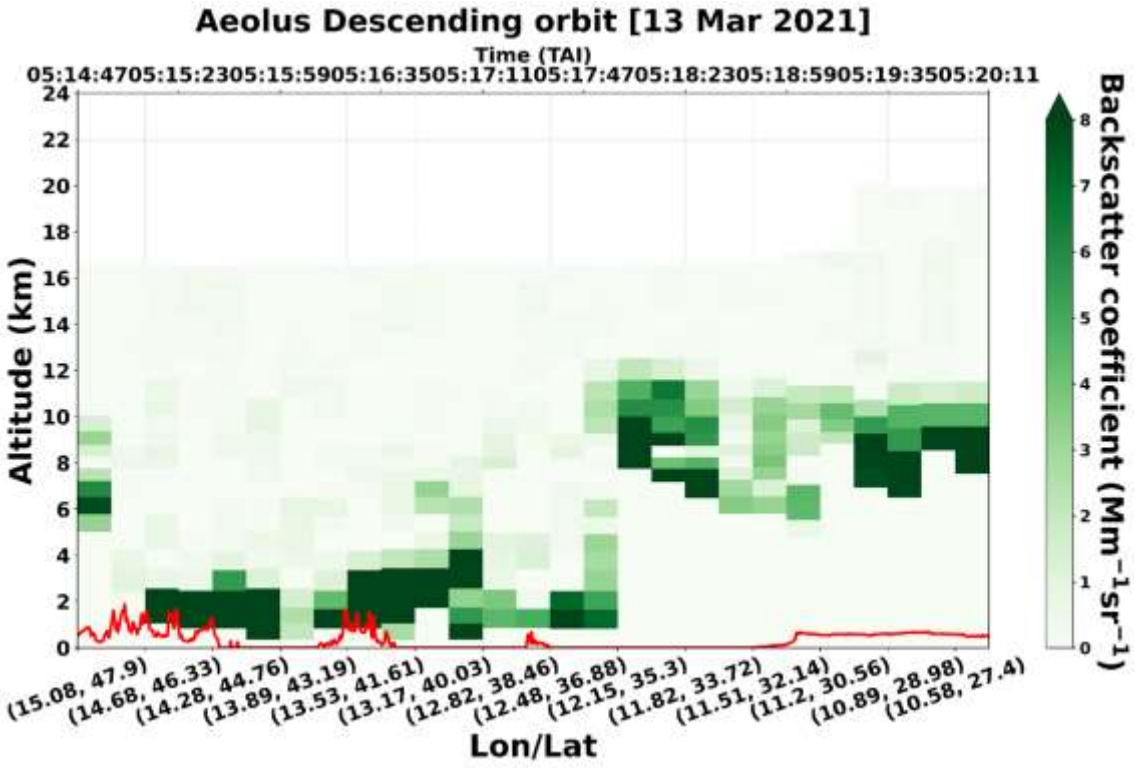


Aeolus raw SCA-ray and SCA-midbin profiles

SCA-ray [24 bins]



SCA-midbin [23 bins]



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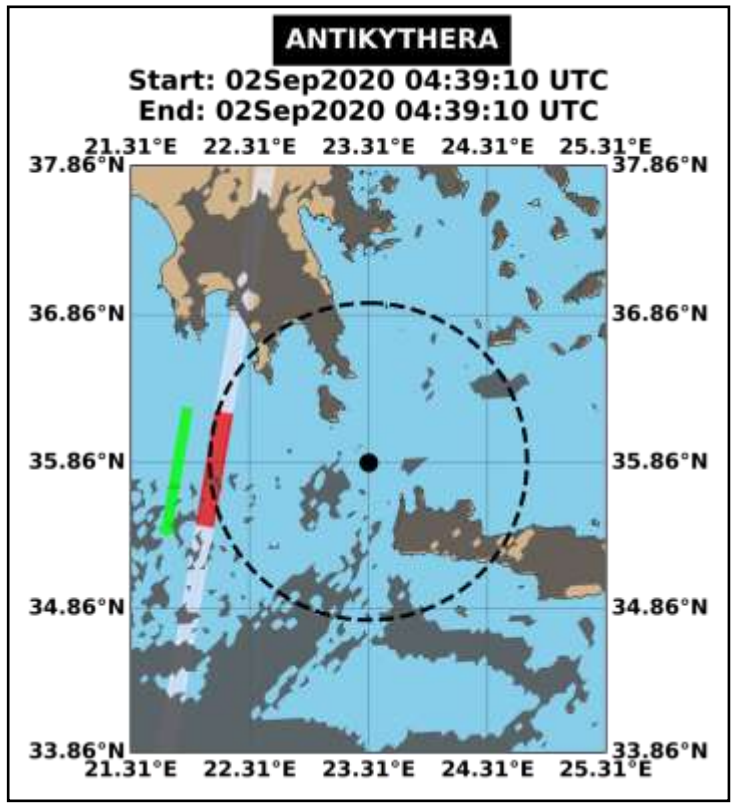
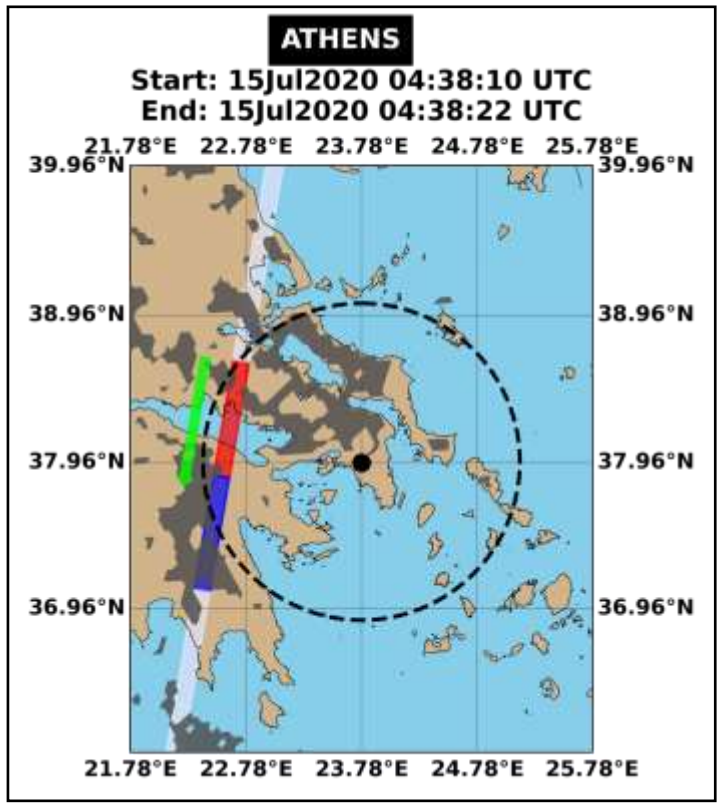
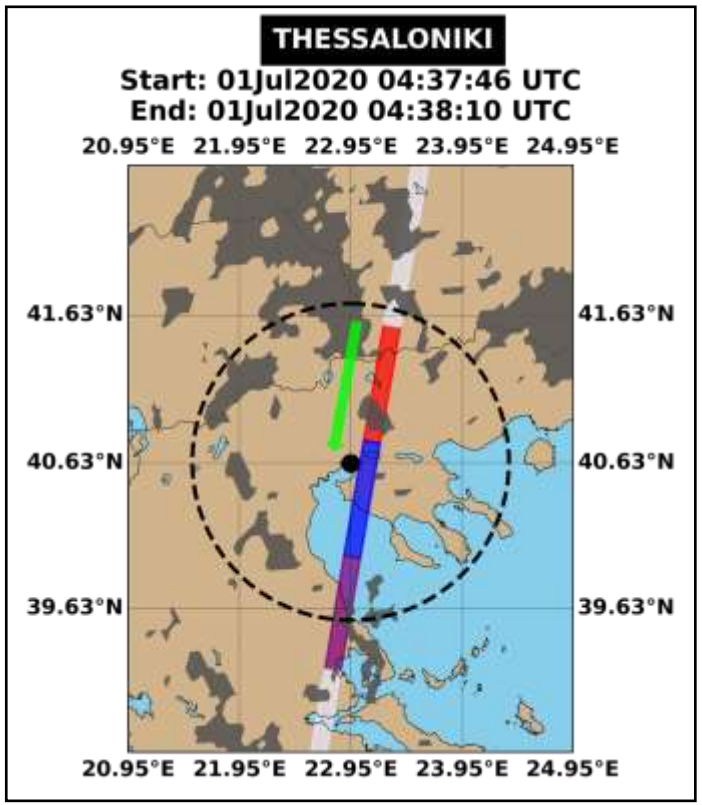
WP3000: *Development of the L2A+ aerosol product.*

Removal of cloud contaminated profiles via the synergy with MSG cloud imagery





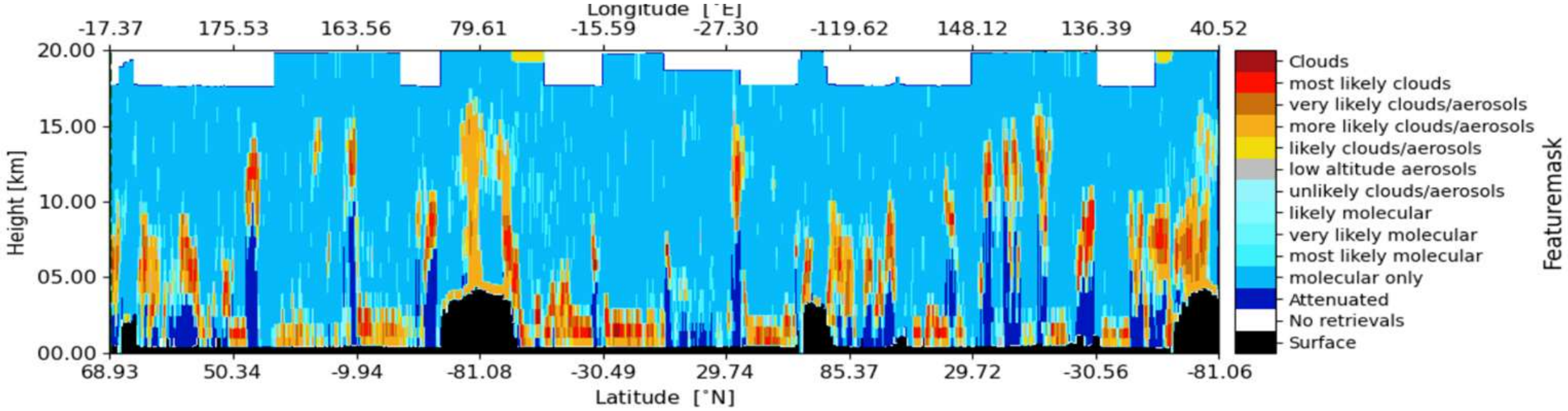


SEVIRI CLAAS-3 dataset

Gkikas et al. (2022) [AMTD]

WP3000: *Development of the L2A+ aerosol product.*

Removal of cloud contaminated profiles via the synergy with AEL-FM



Courtesy Dave Donovan [KNMI]

L2A+

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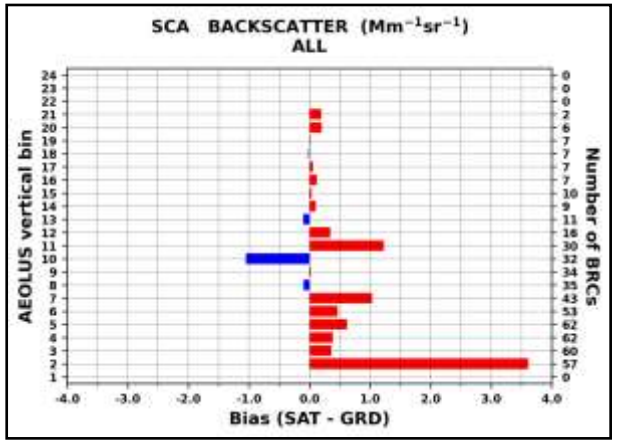
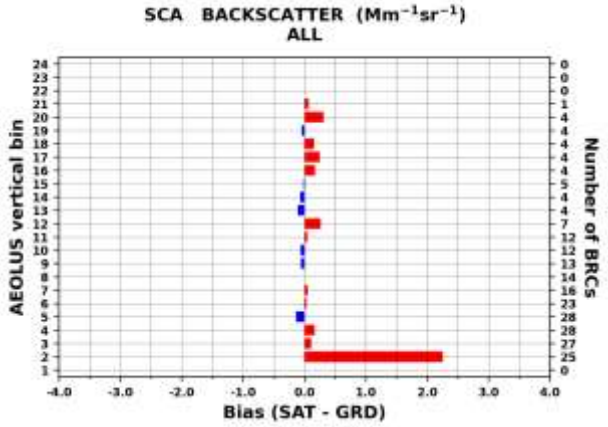
WP3000: *Development of the L2A+ aerosol product.*

Beneficial impact of removing cloud-contaminated Aeolus profiles

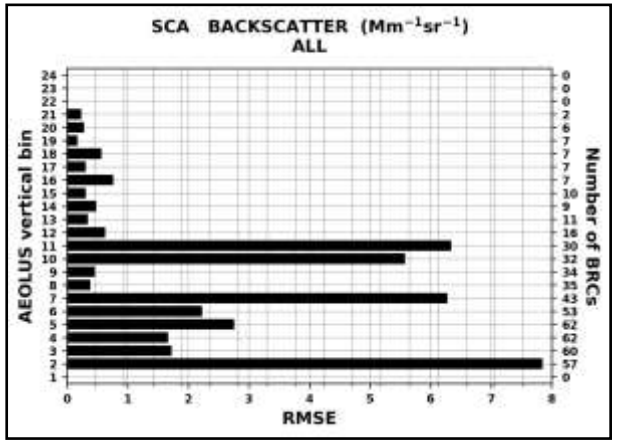
Unfiltered | **Filtered**

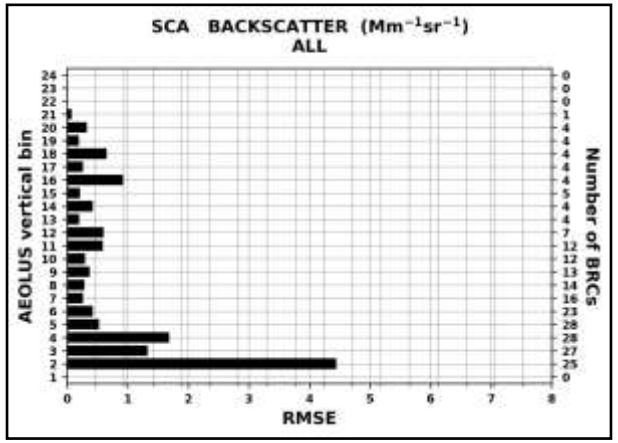
Bias





RMSE





- Substantially better agreement against ground-based lidars after discarding clouds
- The performance at the lowermost bins is still downgraded due to noise even for the filtered Aeolus profiles
- Omit near-surface Aeolus bins in the assimilation experiments

Gkikas et al. (2022) [AMTD]

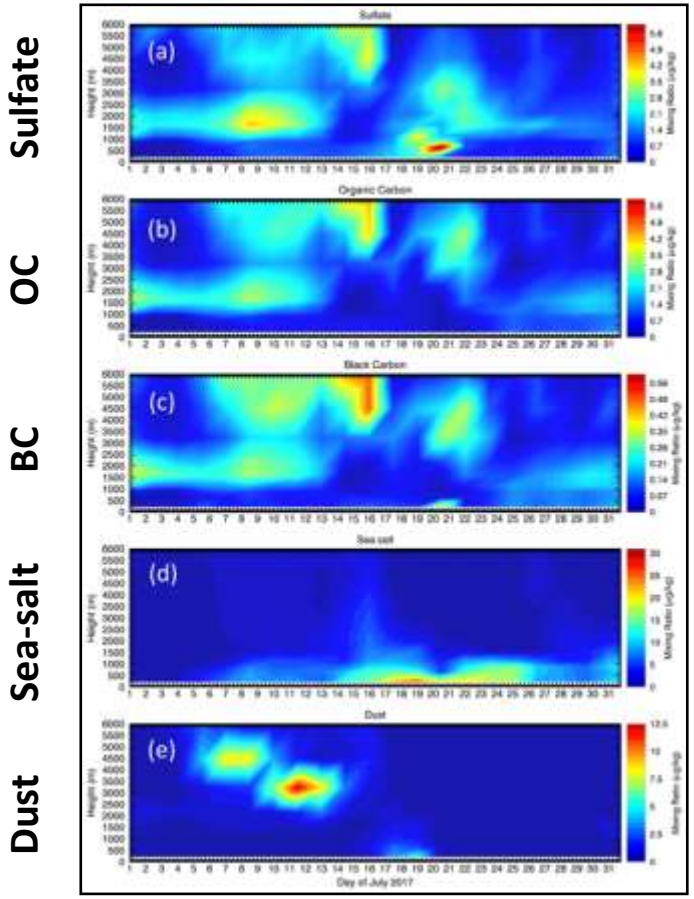
L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

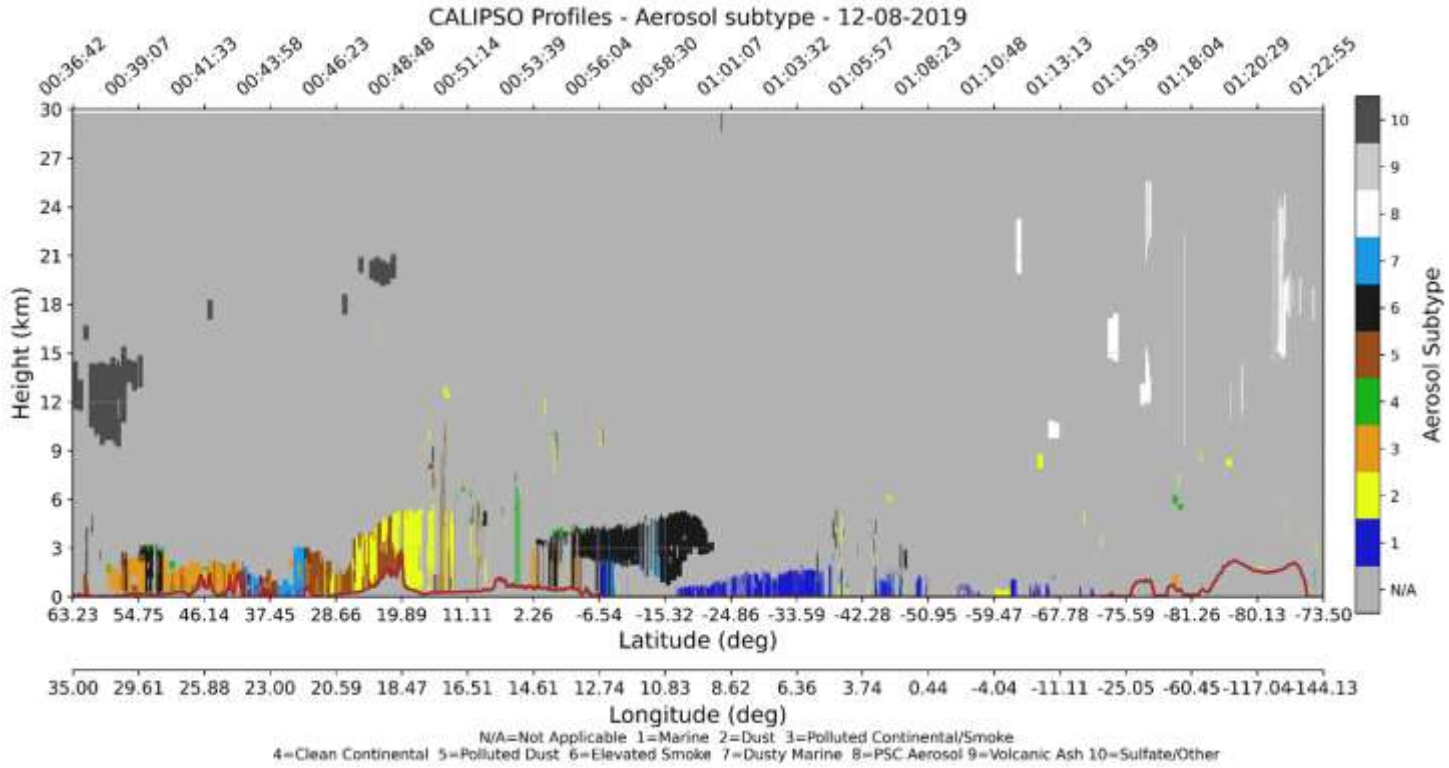
WP3000: *Development of the L2A+ aerosol product.*

Aerosol typing on Aeolus profiles relying on CAMS outputs and/or CALIOP-CALIPSO feature mask

CAMS



CALIPSO

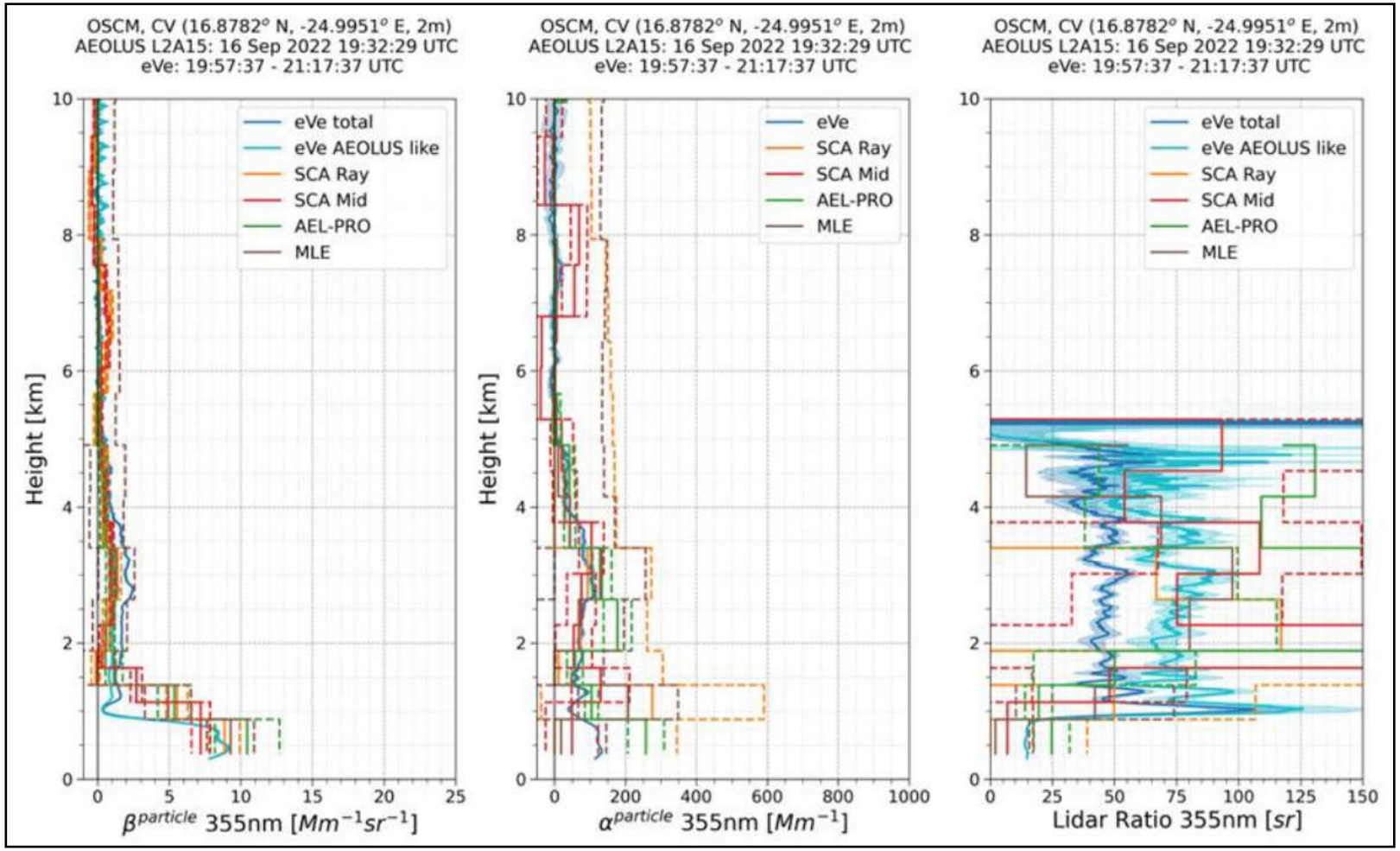


L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP3000: *Development of the L2A+ aerosol product.*

Evaluation of Aeolus L2A+ aerosol (dust) profiles versus eVe and Polly^{XT}



Related Cal/Val studies

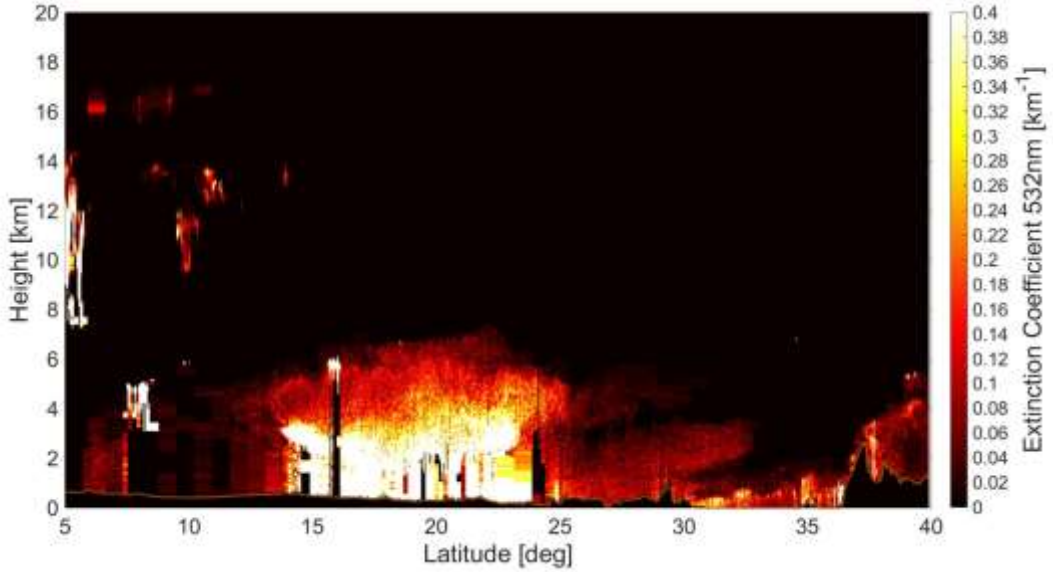
1. *PANACEA (E. Mediterranean)*
1. *EARLINET (Europe)*
1. *Mindelo (Cape Verde)*

Courtesy Peristera Paschou [NOA]

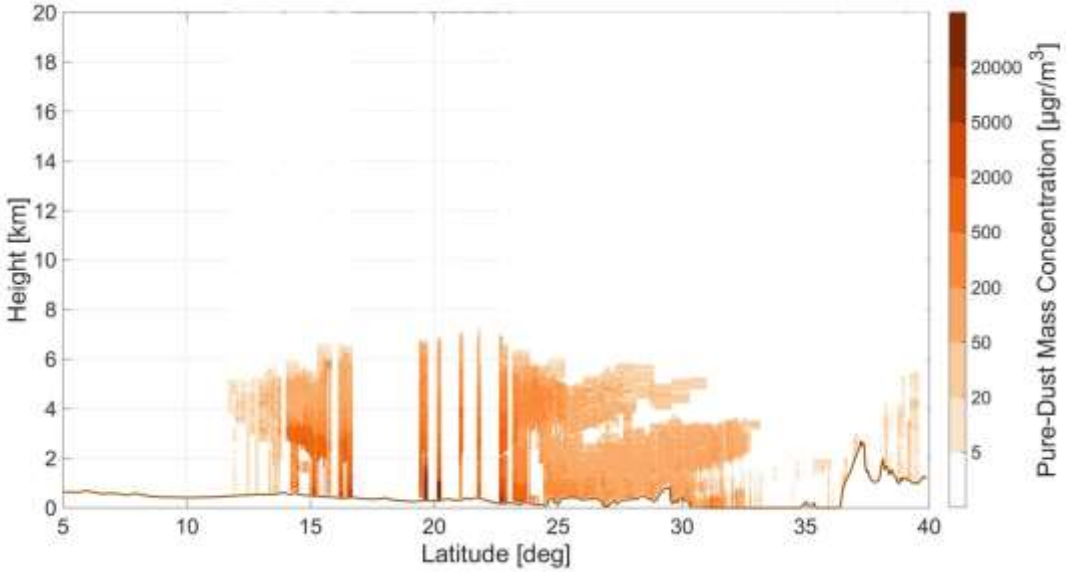
WP3000: *Development of the L2A+ aerosol product.*

Derivation of mass concentration

Extinction coefficient (km^{-1})



Mass concentration ($\mu gr\ m^{-3}$)



Ansmann et al. (2022) [AMTD]

WP4000: *Assimilation of L2A/L2A+ and application of WRF-L experiments.*

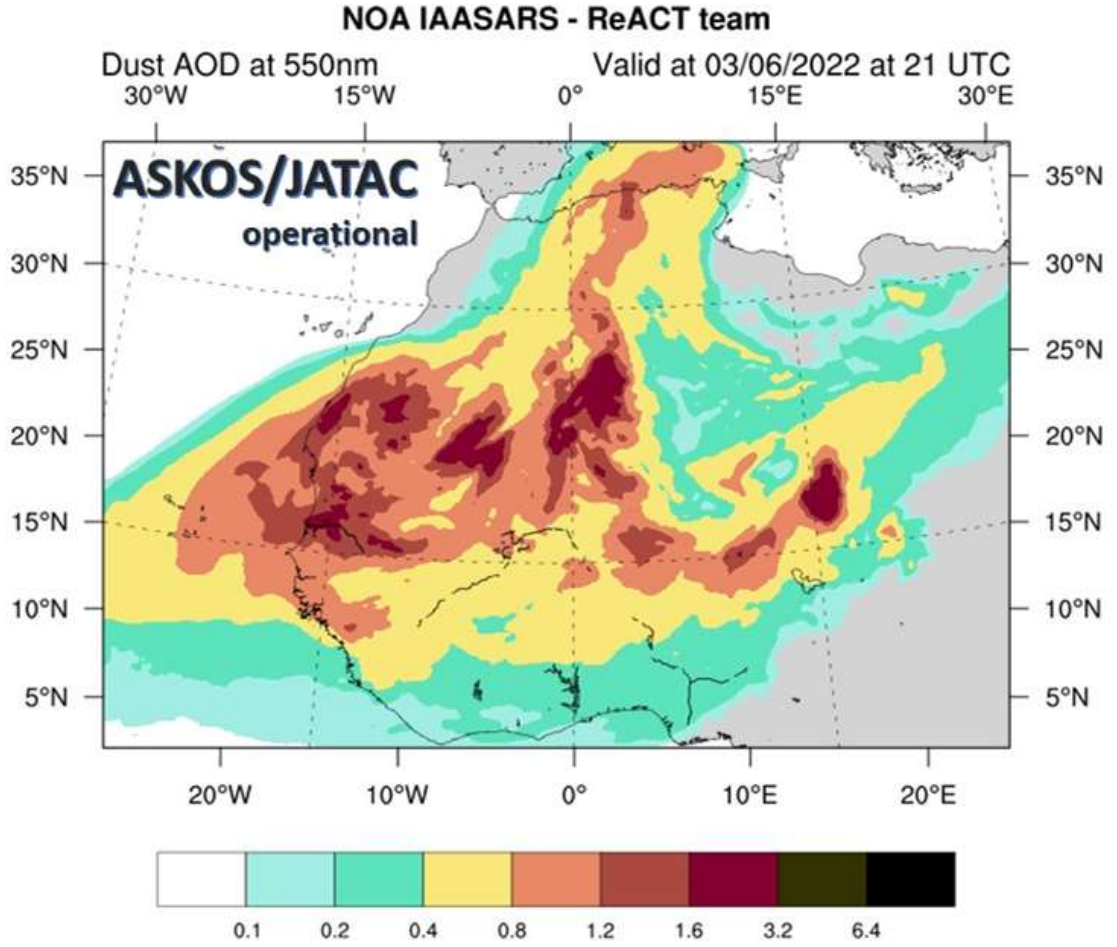
Objective:	Assimilation of L2A/L2A+ and application of WRF-L experiments.
Inputs:	1) Aeolus L2A and L2A+ dust profiles from WP3000 2) ECMWF IFS wind fields with /without Aeolus assimilation (available from ECMWF)
Tasks:	1) Development of data assimilation routines (DART) 2) Evaluation of assimilation methodology 3) Performance of short term dust and NWP forecasts with WRF model.
Output:	DI03: Description of the Algorithm Developments (ALGO) for assimilating Aeolus L2A and L2A+. DI05: WRF simulation outputs for all experiments.

Numerical Modeling

- popular open-source tool (NCAR ,NCEP, NOAA, US. Air Force, Naval Research Laboratory, Univ. of Oklahoma, FAA)

- simulates meteorological conditions, emission, formation, transport, deposition, nucleation and radiation effects of dust, so has a unique advantage in simulating dust process

- scales from tens of meters to thousands of kilometers



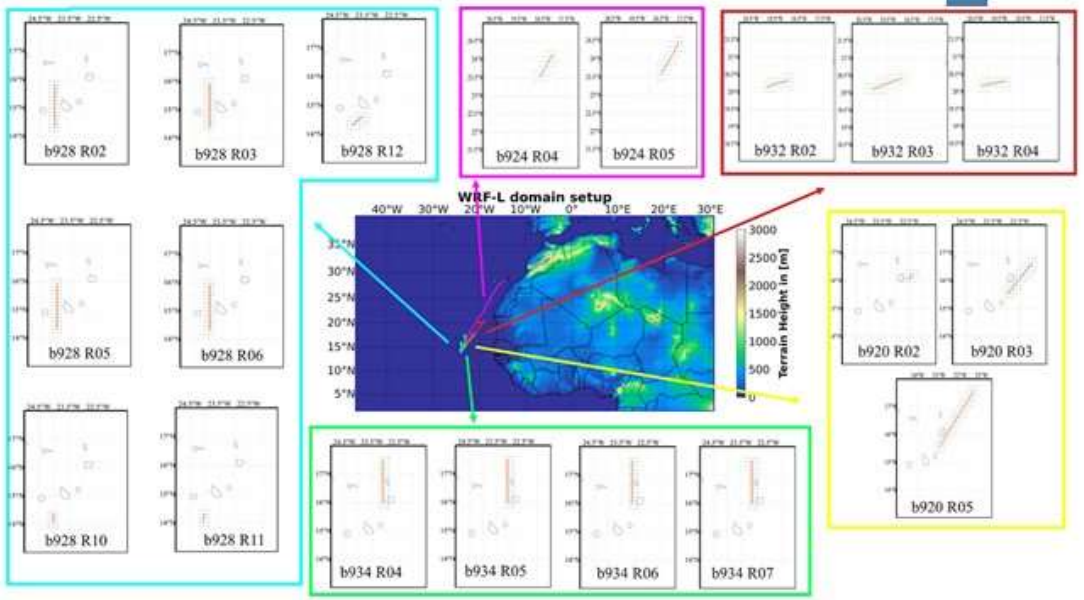
L2A+

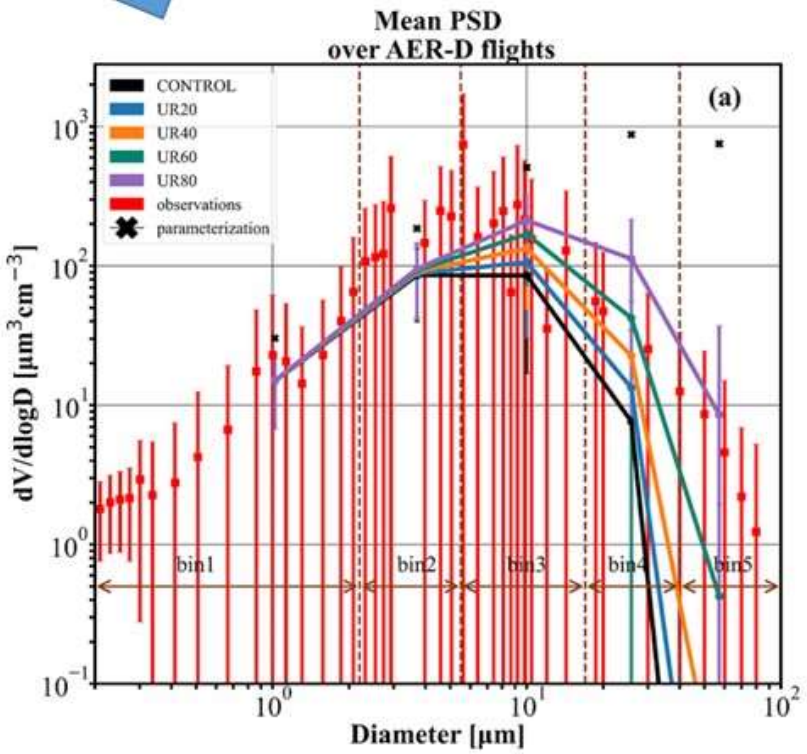
Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP4000: *Assimilation of L2A/L2A+ and application of WRF-L experiments.*

WRF-L can simulate dust particle sizes up to 100μm - is developed targeting on the dust transport processes

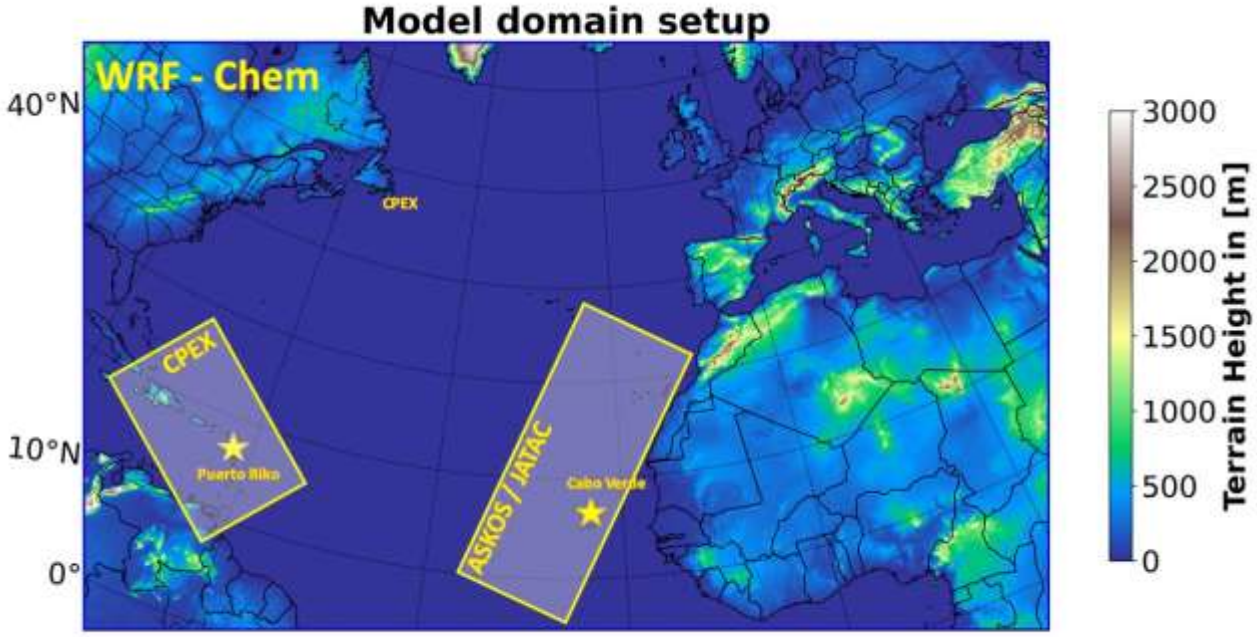
Best model fit to observations for 60-80% reduction of settling velocities

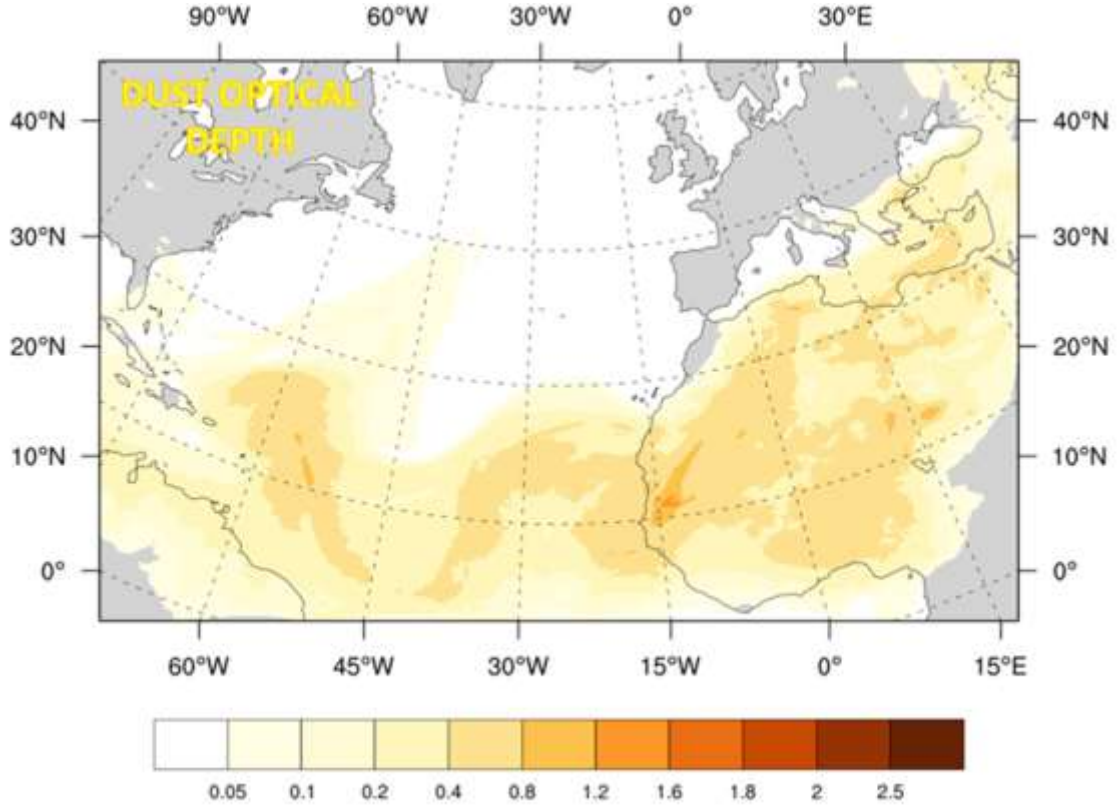




WP4000: *Assimilation of L2A/L2A+ and application of WRF-L experiments.*

A bigger domain for the project that contains all the available observational datasets





L2A+

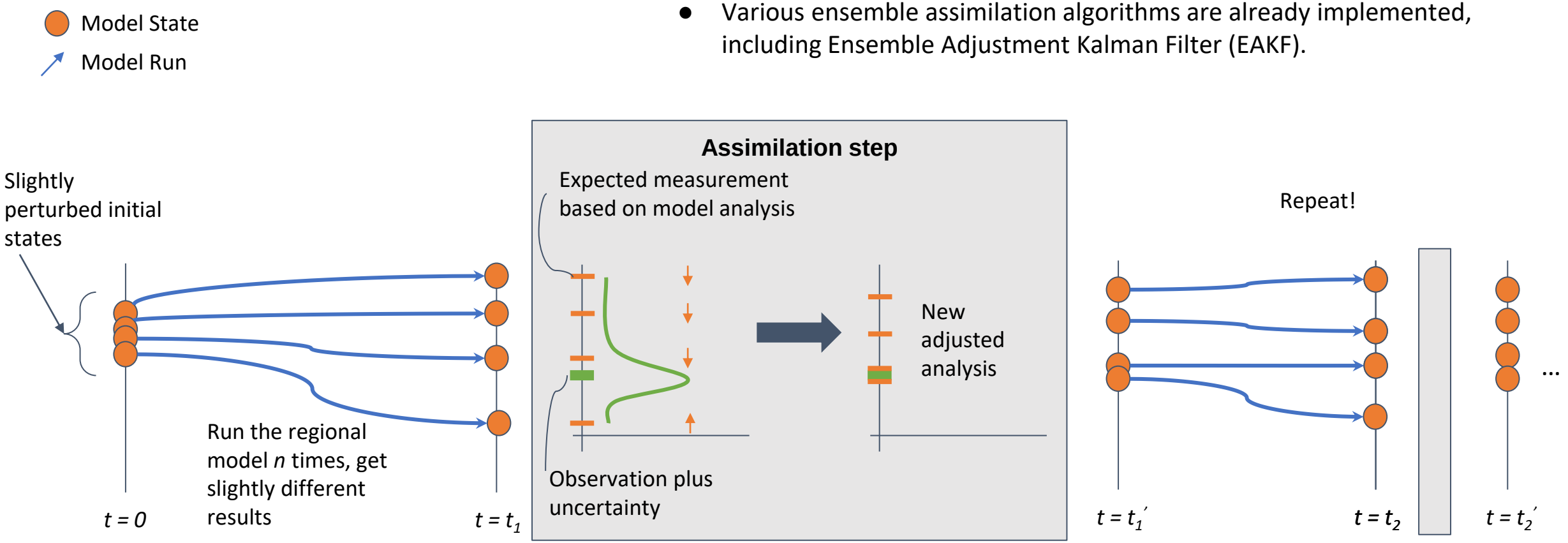
Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

aeolus ECMWF TROPOS

WP4000: *Assimilation of L2A/L2A+ and application of WRF-L experiments.*

NCAR | DART

- The Data Assimilation Research Testbed (DART) toolkit will be used to assimilate the L2A and L2A+ products into WRF-L.
- DART is maintained by the Data Assimilation Research Section at NCAR.
- Various ensemble assimilation algorithms are already implemented, including Ensemble Adjustment Kalman Filter (EAKF).

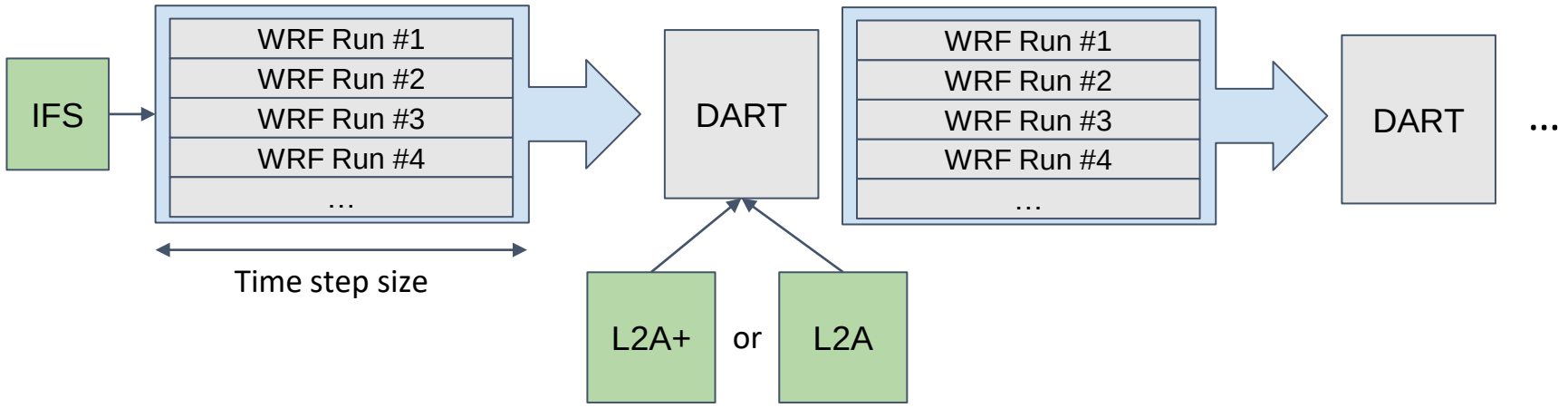


L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP4000: *Assimilation of L2A/L2A+ and application of WRF-L experiments.*

In practice:



Four experiments:

- **CTRL:** Control run without AEOLUS wind field assimilation
- **EXP-0**: Use initial & boundary conditions w/ AEOLUS wind field assimilation
- **EXP-L2A:** Use AEOLUS wind fields and L2A dust product assimilation
- **EXP-L2A+:** Use AEOLUS wind fields and L2A+ dust product assimilation

Practical Issues:

- Select time step size (how often to assimilate L2A/L2A+)
- Select ensemble size (how many WRF analyses to use)
- Select vertical model layers and sync with Aeolus
- …

L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP5000: *Scientific Analysis and Impact Assessment.*

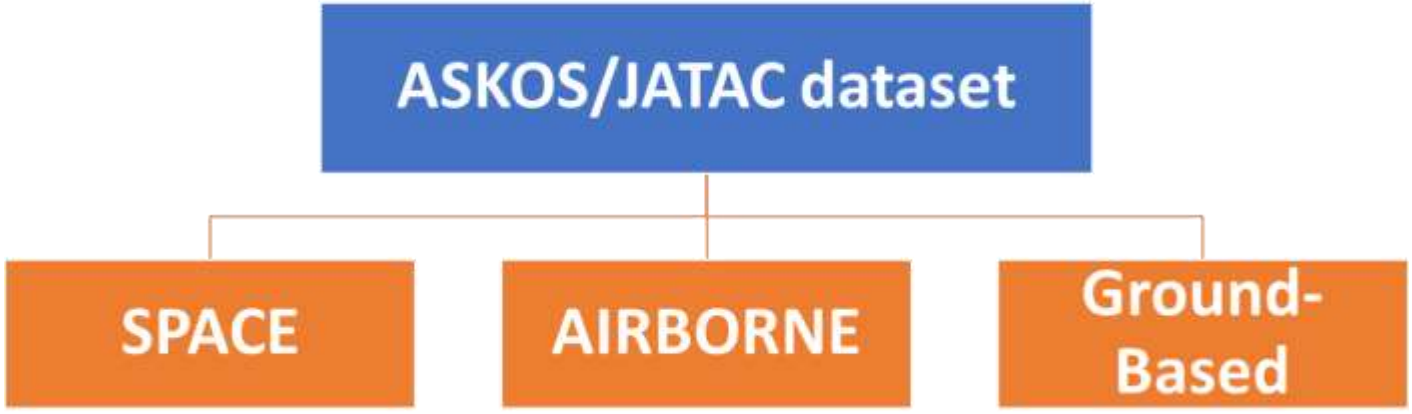
Objective:	To assess the impact of the L2A+ product.
Inputs:	1) DI02: ASKOS observational dataset and Data Pool. 2) DI03: L2A+ Database; L2A+ Database Description Document; L2A+ assimilation outputs - Database; L2A+ assimilation outputs - Database Description Document
Tasks:	1) Assessment of L2A+ assimilation impact on NWP. 2) L2A+ products and quantification of dust deposition variability across the N. Atlantic Ocean. 3) Assessment of the contribution of Aeolus L2A and L2A+ optical properties profile products to the ESA-LIVAS atmospheric aerosol database.
Output:	DI06: Scientific Analysis, Impact Assessment and Scientific Roadmap (SIR), providing: - Impact assessment report of L2A/L2A+ assimilation on Trans-Atlantic dust transport and NWP. - Evaluation Report on L2A/L2A+ dust deposition fields. - Integrated database of L2A, L2A+, and ESA-LIVAS optical products. - Assessment Report on the integration of L2A/L2A+ optical products to the ESA-LIVAS database.

L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP5100:	*Scientific Analysis and Impact Assessment.*

Assessment of L2A+ assimilation impact on NWP.



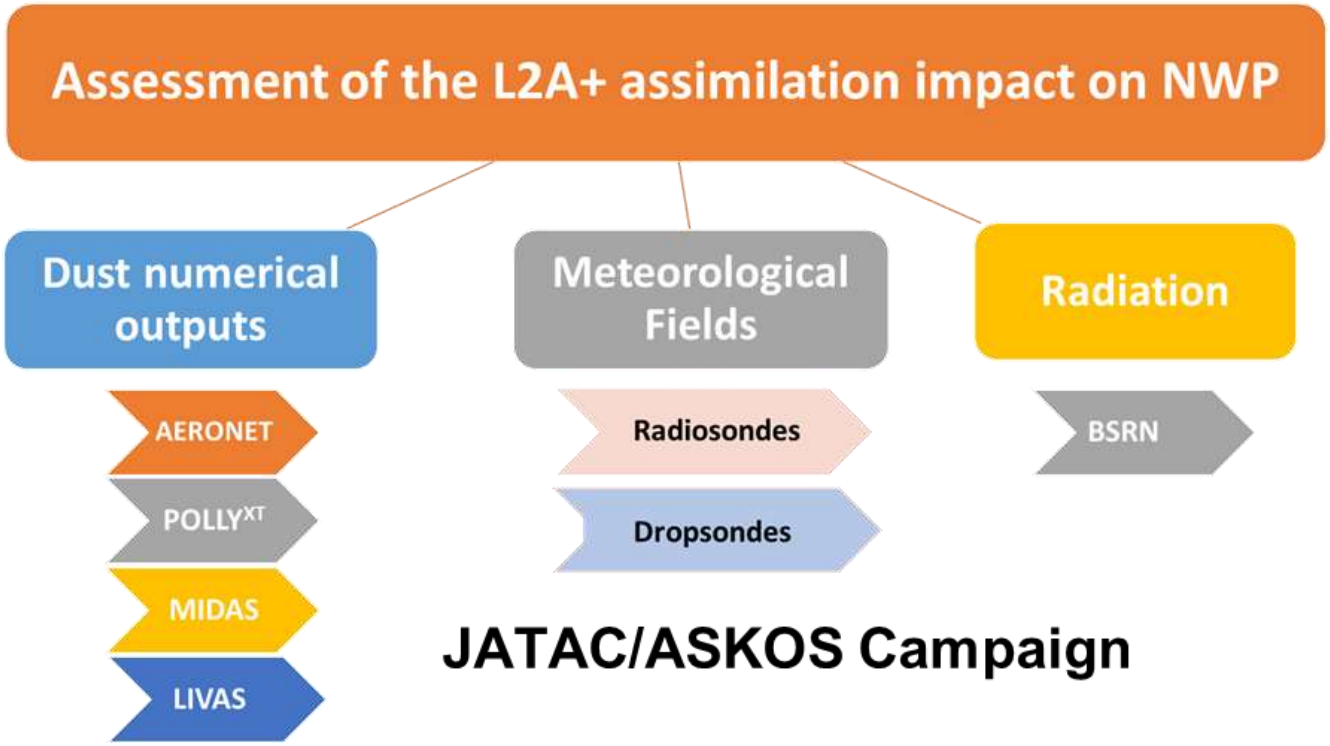
- **aerosol** profiles from *ground-based lidar* measurements
- **water-vapour** profiles
- **wind** profiles from *HALO*
- **radiosondes** launched at Sal Island
- **airborne dropsonde** datasets
- **radiation** measurements

L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP5100:	*Scientific Analysis and Impact Assessment.*

Assessment of L2A+ assimilation impact on NWP.



➢ **L2A+ assimilation impact on desert dust transport**

- **Ground-based retrievals** (**eVe** & **Polly^{XT}**)
- **Columnar and vertical resolved dust fraction** above Mindelo & **LIVAS, AERONET, MIDAS** datasets

➢ **L2A+ assimilation impact on NWP**

- **Radiosonde & wind lidar data** to examine the impact on **Temperature** & **Wind patterns**.
- **Water Vapour profiles** & **Cloud Radar** datasets to quantify potential changes on **Clouds & Atmospheric Humidity**

➢ **L2A+ assimilation impact on Radiation**

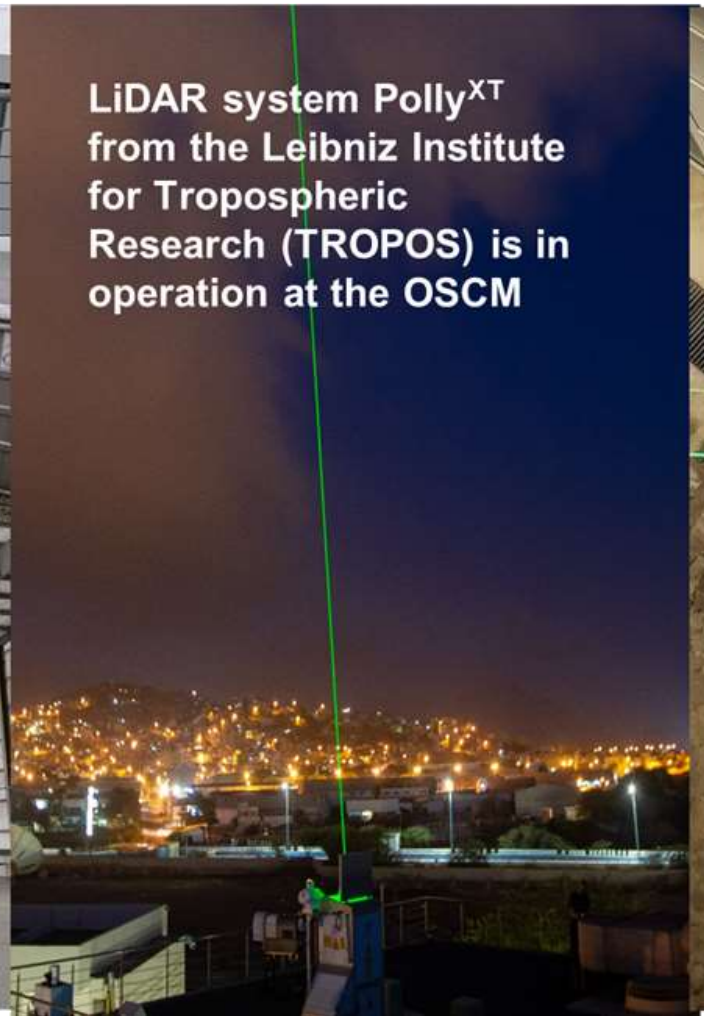
- **Radiation measurements in Mindelo**

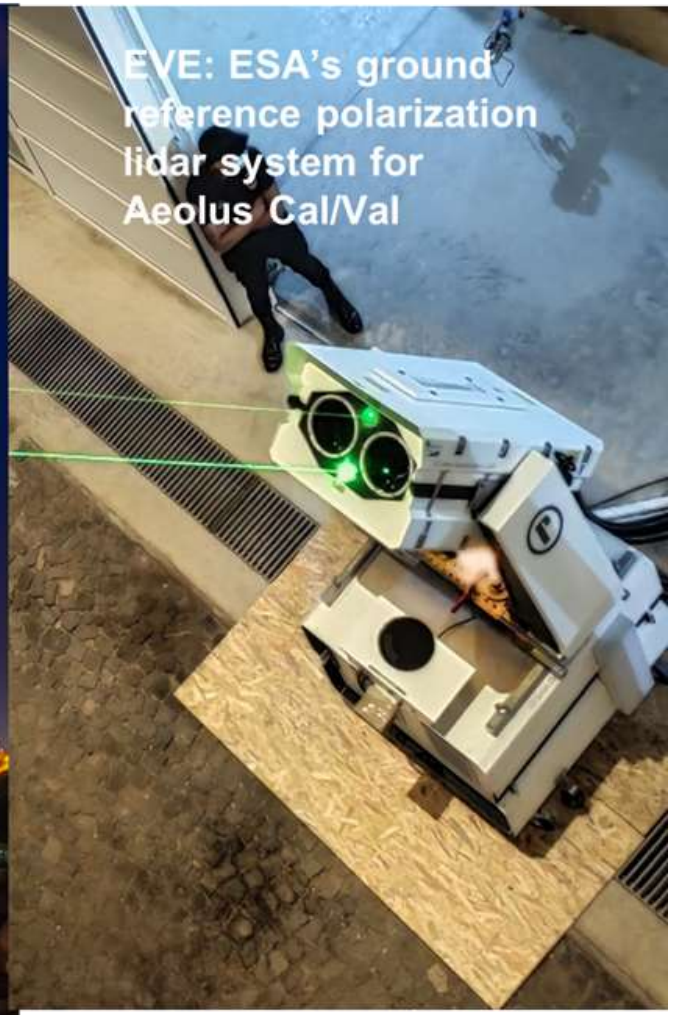
L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP5100:	*Scientific Analysis and Impact Assessment.*

Assessment of L2A+ assimilation impact on NWP.





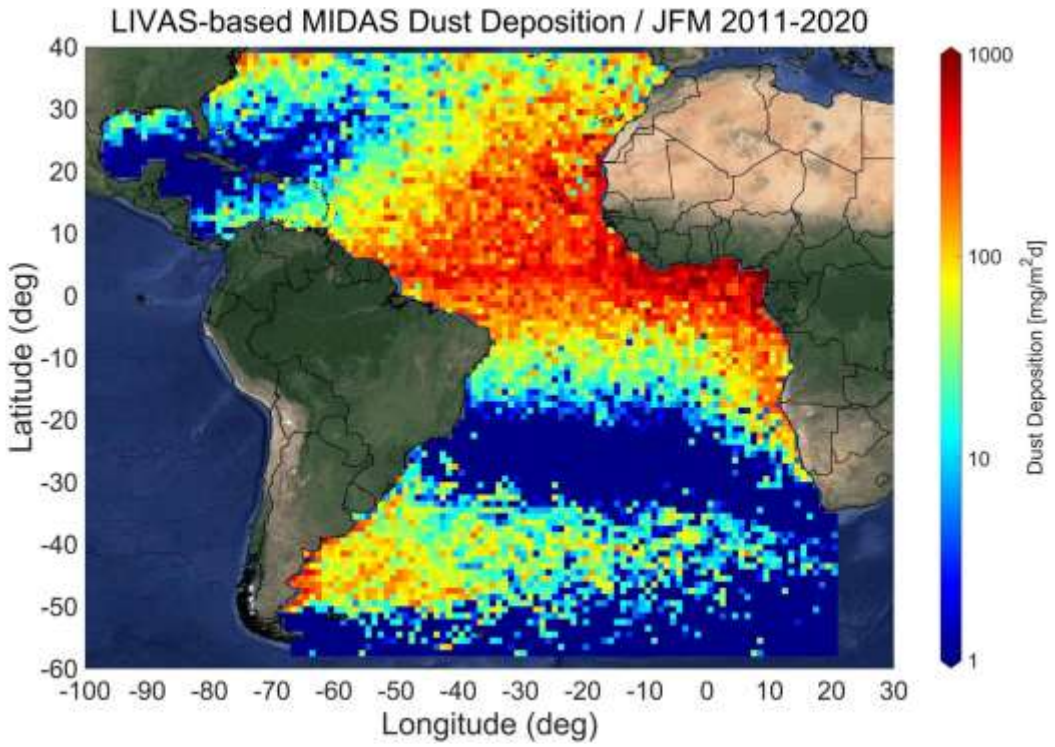
L2A+

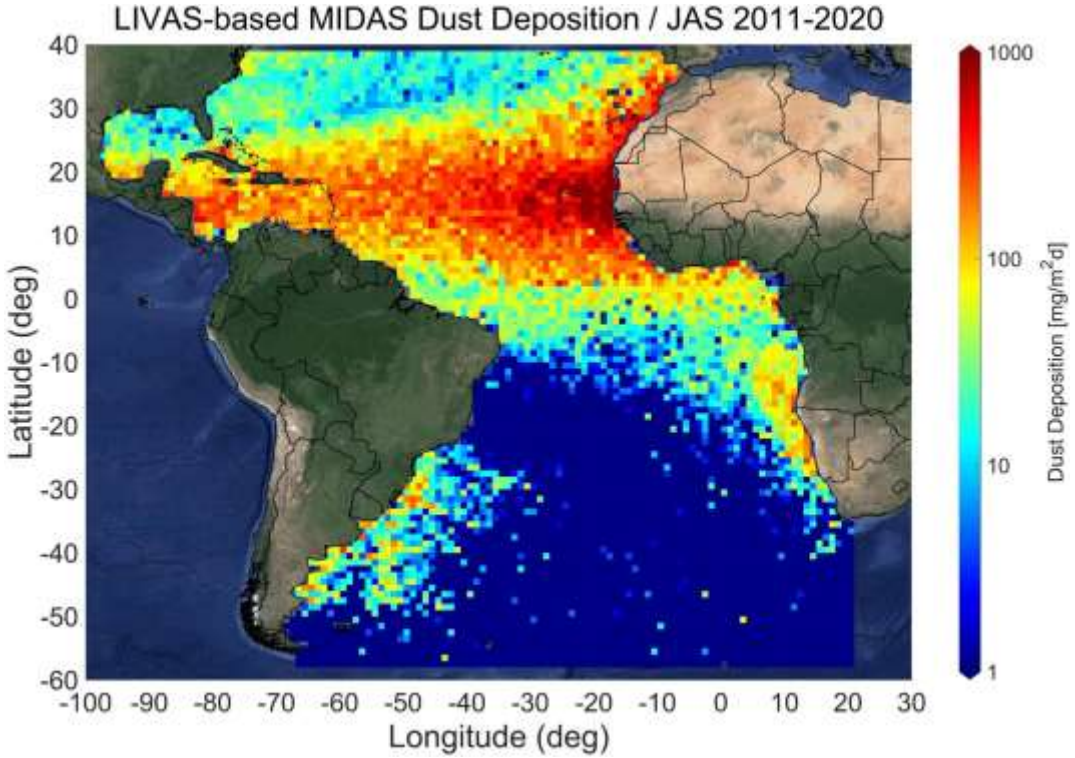
Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP5200: *Scientific Analysis and Impact Assessment.*

L2A+ products and quantification of dust deposition variability across the N. Atlantic Ocean.

The ESA-DOMOS project: To create a unique 4D-reconstruction of the dust full cycle including deposition based on the synergy of models and observations including vertical profiling through the use of advanced retrieval methods and of 4D-Var and Ensemble Kalman Filter analyses.





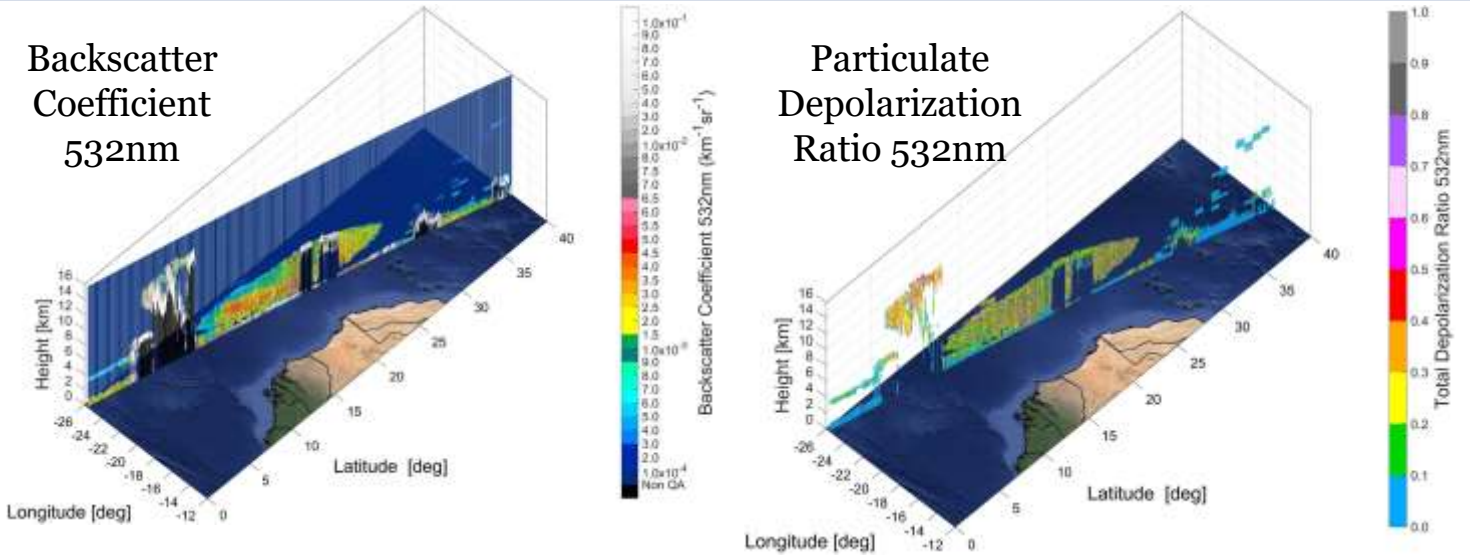
L2A+

Enhanced Aeolus L2A for depolarizing targets and impact on aerosol research and NWP.

WP5300: *Scientific Analysis and Impact Assessment.*

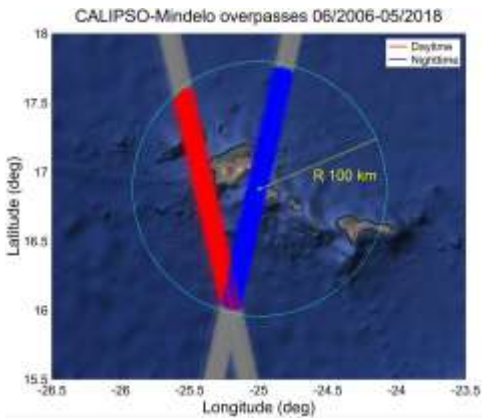
Assessment of the contribution of Aeolus L2A and L2A+ optical properties profile products to the ESA-LIVAS atmospheric aerosol database.

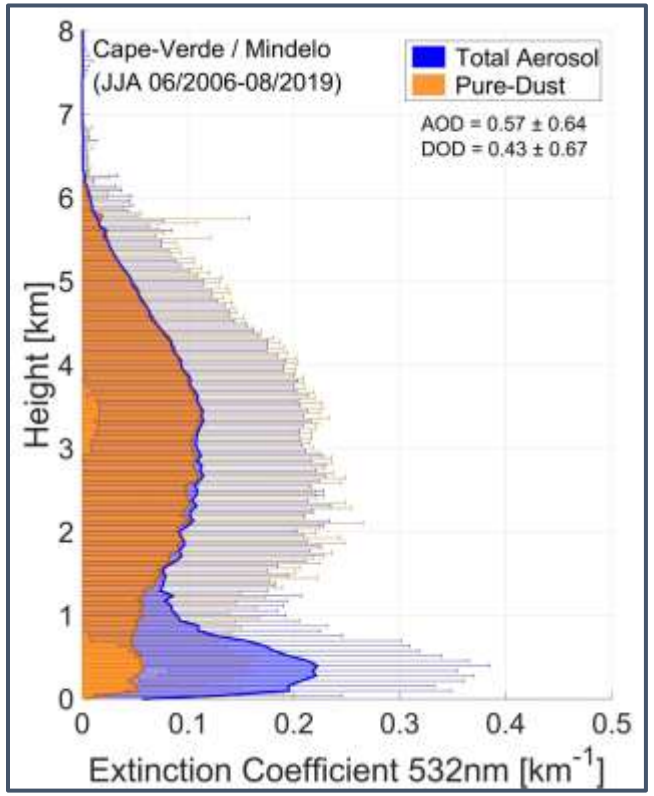
Backscatter Coefficient 532nm



Particulate Depolarization Ratio 532nm

multi-year CALIPSO overpasses





WP6000: *Recommendations*

Objective:	Summary of the main scientific outcomes of the project and recommendations for expanding the performed research activities.
Inputs:	1) All Deliverable Items. 2) Outputs from WP2000, WP3000, WP4000 and WP5000.
Tasks:	1) A synthesis and recommendation report summarising all the results from input WPs. 2) Synthesis of the final Analysis Report of the Validation activities carried out 3) A scientific roadmap for future studies in the relevant research area. 4) Based on the obtained findings, suggestions for improving Aeolus observational capabilities will be provided to the Agency. 5) Promotion of L2A+ data exploitation in atmospheric research.
Output:	• DI04: Analysis of the Validation Activities carried out (VAL). • DI09: Final Report (FR).