ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

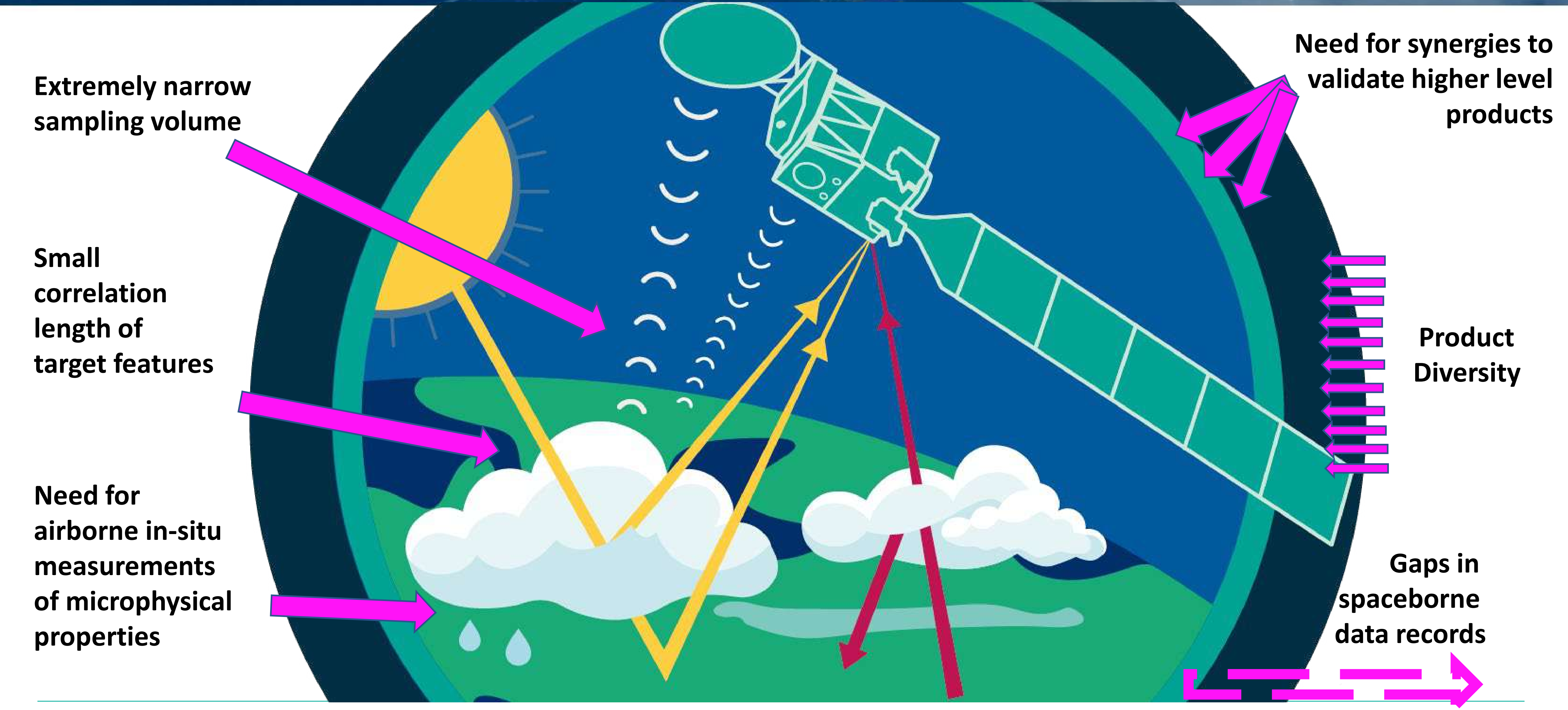
13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

The ACPV activity:

Defining validation protocols for spaceborne aerosol and cloud profile products

Vassilis Amiridis, Eleni Marinou, Holger Baars, Stephanie Rusli, Rob Koopman
and the ACPV community

Validation challenges for aerosol and cloud profiling



EarthCARE and AOS scientists' recommendations

ACCP (now **AOS**) 2nd Sub-orbital Workshop, April 2021

ACCP Agenda Day 5 (April 16, 2021)

Science Data Validation

All times Eastern Daylight Time (U.S., New York City)

10:00 Welcome and Objectives for the day
- Walt Petersen

10:05 Discuss needs and high-level strategies for Science Validation:
(Consider pre and post Launch; what would we do similarly or different from previous validation efforts in other missions?)
- Facilitator Aerosols: Rich Moore, Joe Munchak — Rapporteur: Walt Petersen

11:05 Identify Synergies with Science Implementation Plans (data, instruments, platform sampling synergies etc.) from Days 2, 3, 4
- Facilitators: SOWG Committee — Rapporteurs: Jens Redemann, Sebastian Schmidt

12:05 Establish Science Validation Strategies (Pre and Post Launch), Implementation, Cost
- Facilitating Panel: SOWG Committee — Rapporteur: Allison McComiskey, Rob Wood

13:30 End Workshop

1. **Need for convergence on common Cal/Val practices acknowledging:**
    - Lessons learned
    - Methods and approaches
    - In-orbit & pre-launch validation
    - Airborne campaigns & networks

2. **Consolidation of best practices in a CEOS level document**
    - There is no CEOS document for profilers (validation documents include at the moment Soil Moisture, Biomass, Albedo, LST, LAI and oceanographic parameters)

Building a network for common/best Cal/Val practices

ACPV:
100 scientists from Space Agencies, CALIPSO, Cloudsat, Aeolus, EarthCARE, AOS missions Research Organizations, RIs, airborne facilities, international networks

Support of the networking activities

Establish a core implementation group

Foster community convergence: **45 community meetings organized**

Document the consensus for CEOS: **7 chapters are being written**

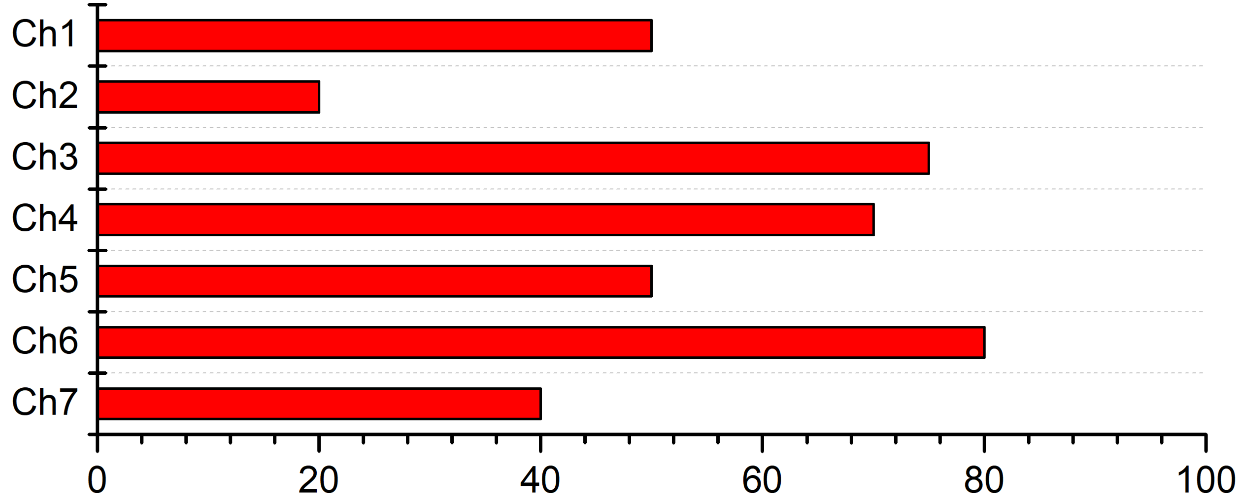
Promote the implementation of ACPV best practices in the wider communities: **conference presentations, Special Issue in AMT**

Progress on CEOS document implementation

ACPV Document Chapters

Ch1. Introduction
Ch2. Validation needs for Space Profilers
Ch3. Survey of validation measurements
Ch4. Correlative metadata and data format
Ch5. Guidance for validation
Ch6. Near-real time validation through data assimilation
Ch7. Knowledge and data gaps

Progress by chapter



2022	2023				2024			
Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
ToC and author list finalized	Community meetings and writing	Community meetings and writing	Community meetings and writing	Community meetings and writing	**First document to be delivered**	Reviews from appointed Reviewers and Cal/Val teams	Revisions	**Final version delivered to CEOS**

CEOS document - Content

Chapter 1: Introduction
[Vassilis Amiridis, Dan Cecil, Rob Koopman]

- Overview of past, present, future space missions for aerosol, cloud and precipitation profiling
- Validation objectives for space profilers
- Cal/Val definitions/nomenclature and validation metrics

Chapter 2: Validation needs for Space Profilers
[Luca Baldini, Tristan l'Ecuyer, Hajime Okamoto]

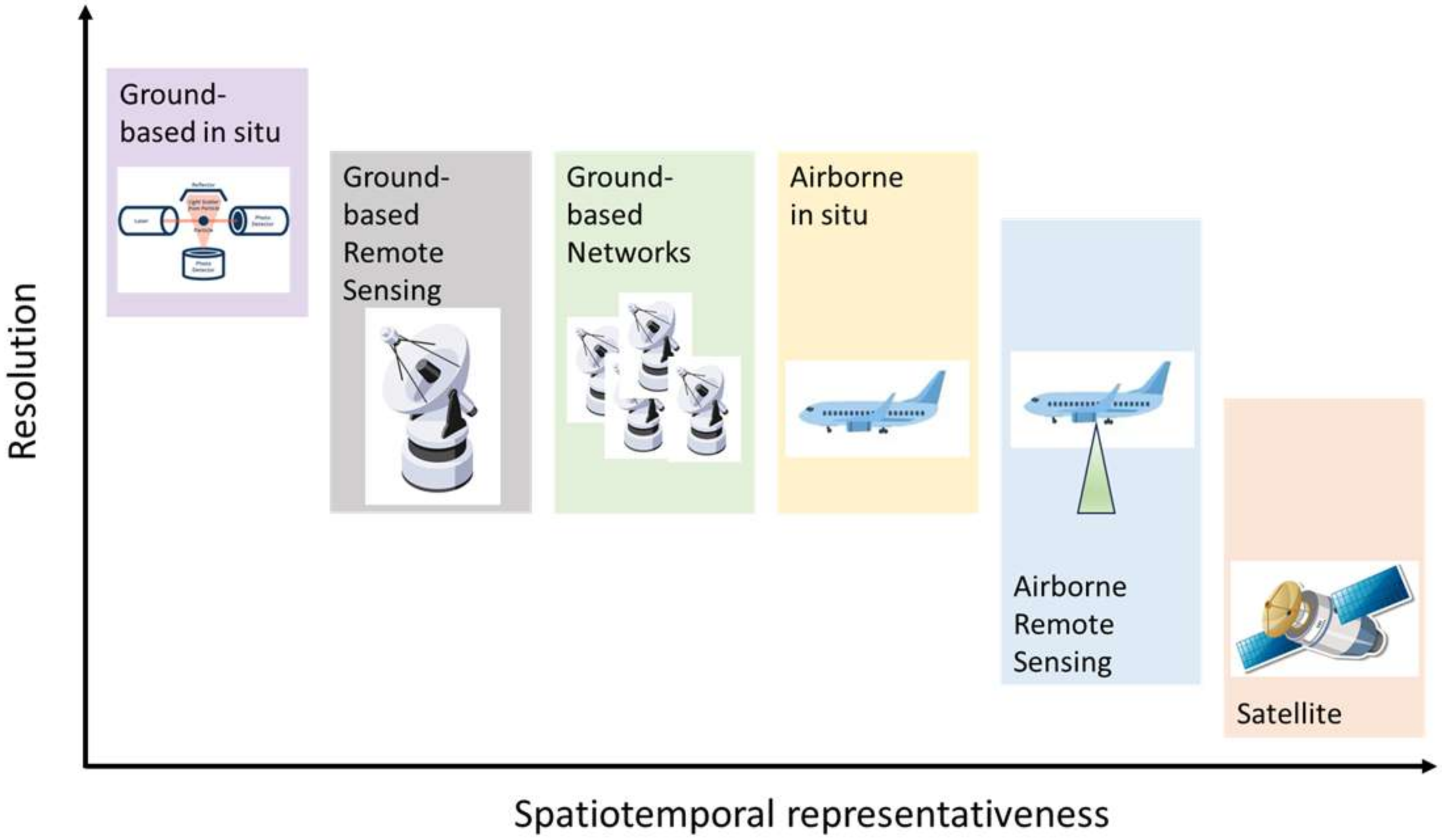
- Detailed list of products from space profilers
- Uncertainties in satellite observations
- Validation needs from the product developer perspective

CEOS document - Content

Chapter 3: Survey of validation measurements

[Jens Redemann, Silke Gross]

- Types of validation instruments
- Quality of measurements
- Spatiotemporal representativeness



Chapter 4: Correlative metadata and data format

[Ewan McGregor, Ann Mari Fjæraa, Michael Shook, Giri Prakash, Lucia Mona]

- Guidelines on EVDC and how to upload datasets to the Cal/Val archive (see also the talk of Ann Mari)

CEOS document - Content

Chapter 5a: Guidance for Validation: Aerosols
[Eleni Marinou, Simone Tannelli]

- Guidelines for sub-orbital aerosol measurements
- Suggested QA/QC procedures
- Spatiotemporal criteria

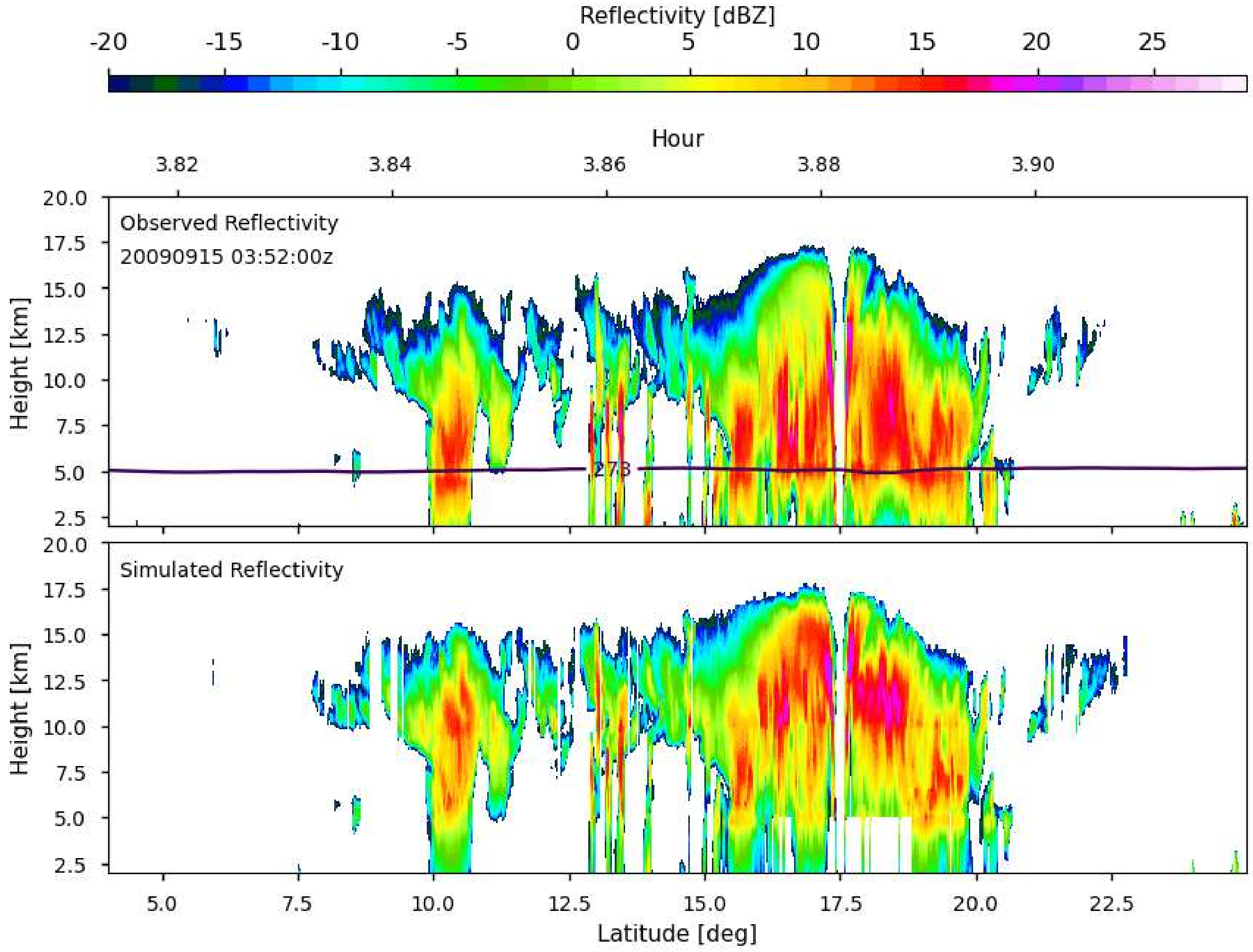
Chapter 5b: Guidance for Validation: Clouds
[Dmitri Moisseev, Eleni Marinou, Simone Tannelli]

- Guidelines for sub-orbital cloud precipitation measurements
- Suggested QA/QC procedures
- Spatiotemporal criteria

CEOS document - Content

Chapter 6: Near-real time validation through data assimilation
[Marta Janiskova, Isaac Moradi]

- Observation simulators
- Validation through monitoring
- Demonstration of monitoring benefits



CEOS document - Content

Chapter 7: Knowledge and data gaps [Holger Baars, Pavlos Kollias, Jay Mace]

- Open issues in Cal/Val
- Under-sampled areas
- Harmonization aspects on different datasets, wavelengths and parameters for bridging missions towards delivering multi-mission climate data records

Gap	Description	Foreseen solution
General		
Spatiotemporal representativeness	How representative is a ground based station with respect to the surrounding	Analyze Cabo Verde data as an example and compare statistics with CALIPSO on different validation radii.
Aerosol profiling-related		
Wavelength dependence of aerosol mixtures	We have a good data set of optical properties at different wavelengths for specific, mostly pure aerosol types (e.g. ACTRIS). But we have not yet this information fully available for aerosol mixtures.	Identify frequent aerosol mixtures. Calculate optical properties based on mixing rules and mixing state out of optical properties from pure types. Compare to existing high quality observations, e.g. ACTRIS.
Cloud and precipitation profiling related		
Validation of CPR velocity products	Since EarthCARE is the first Doppler radar in space, there are no methods previously developed for the validation of spaceborne Doppler radar observations.	Develop a method to derive terminal fall velocities of raindrops from dual-polarization weather radar observations.

ACPV studies

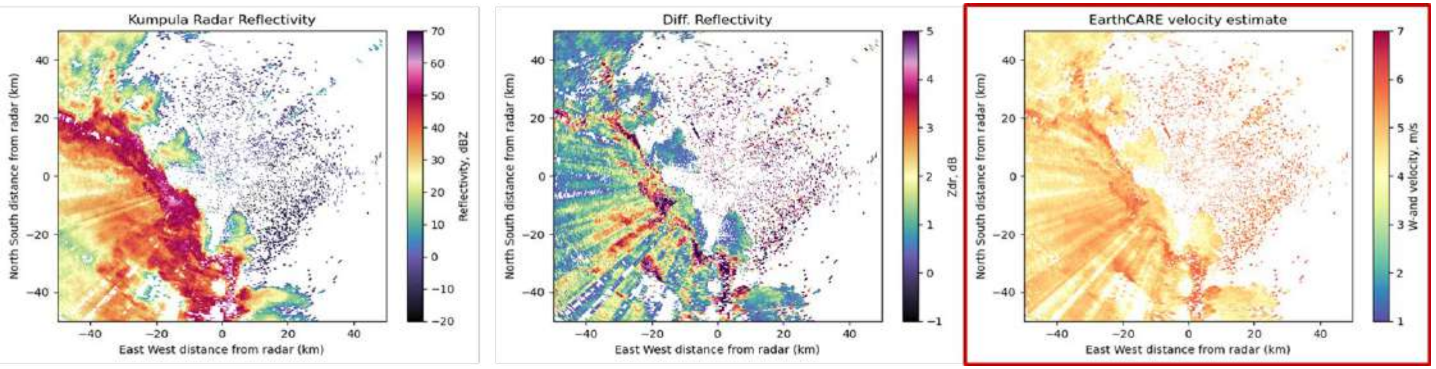
Three (3) selected studies on historical data to fill gaps identified in ACPV:

1. Validation of CPR Doppler velocity and fall velocity products (Led by FMI, contributions from CNR, NOA)

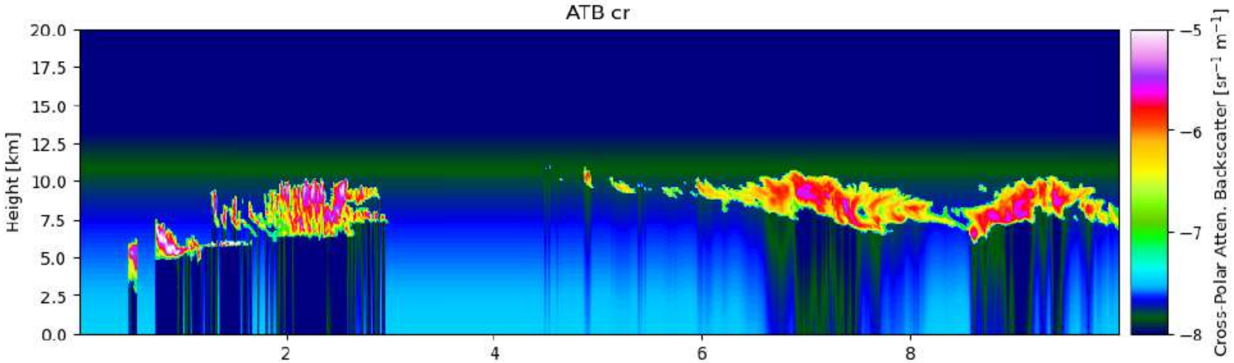
2. Validation of Level 1 lidar products with ground-based systems using the CARDINAL level 1 tool (Led by NOA)

3. Spatiotemporal aerosol representativeness based on ground-based observations and CALIPSO (Led by TROPOS, contributions from NOA)

More on the talk of **Dmitri Moisseev** (Friday morning)

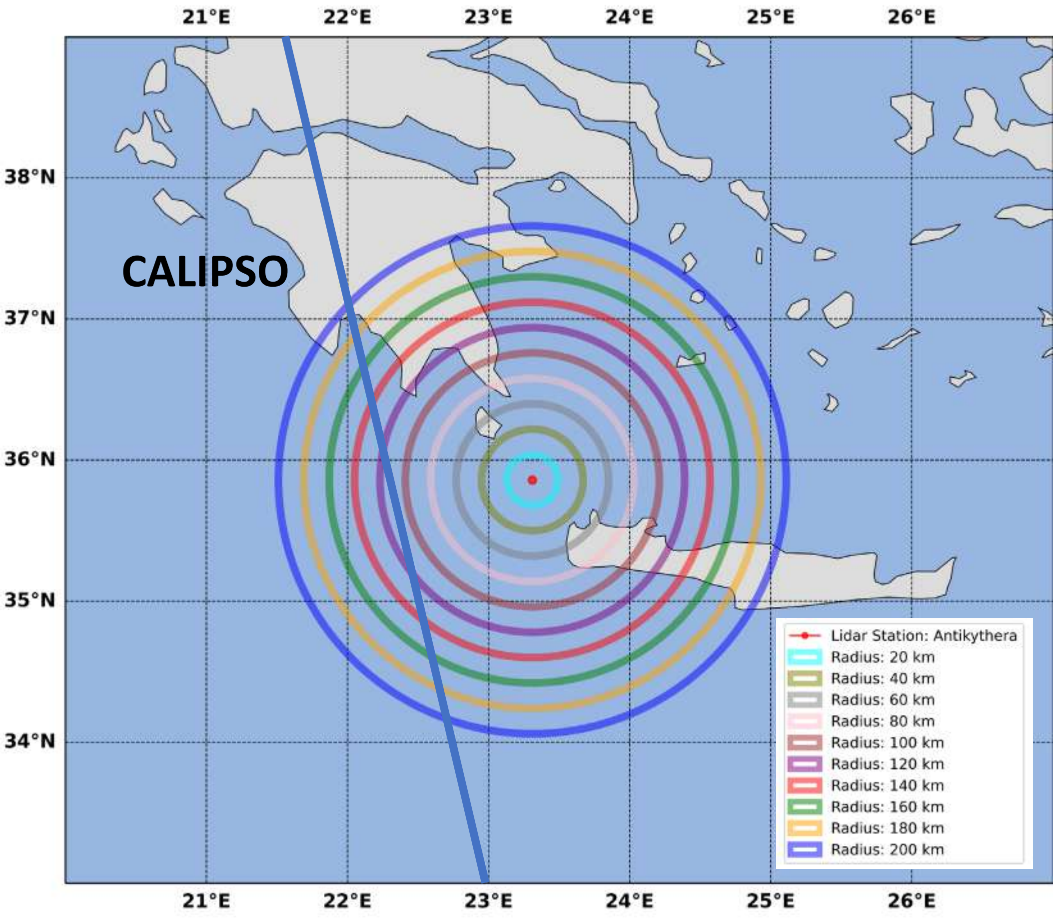


P. Pachou: Use of eVe ground-based lidar measurements from eVe ESA lidar system to reproduce EarthCARE L1 through the EarthCARE simulator

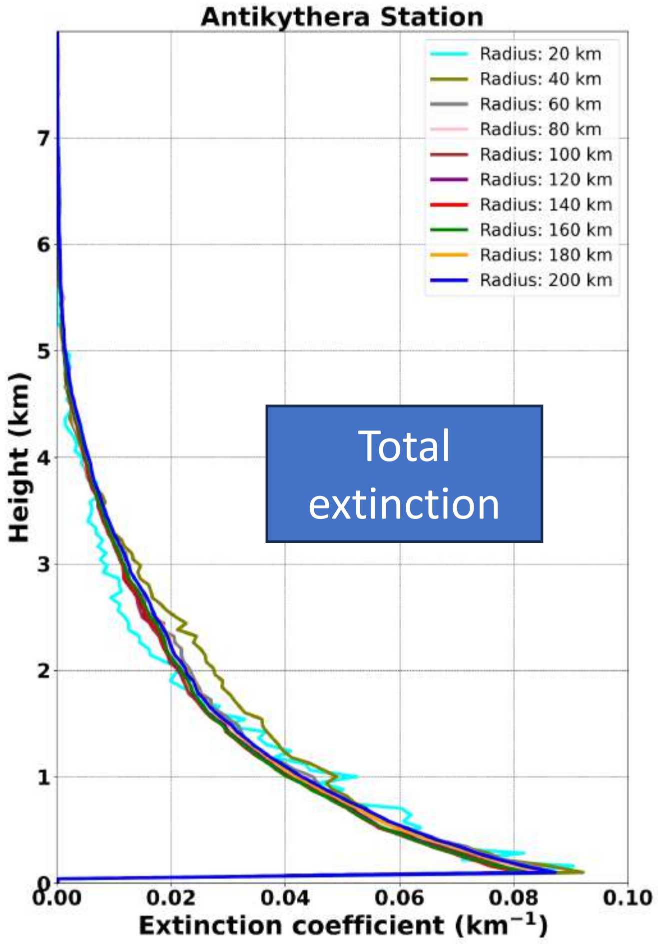


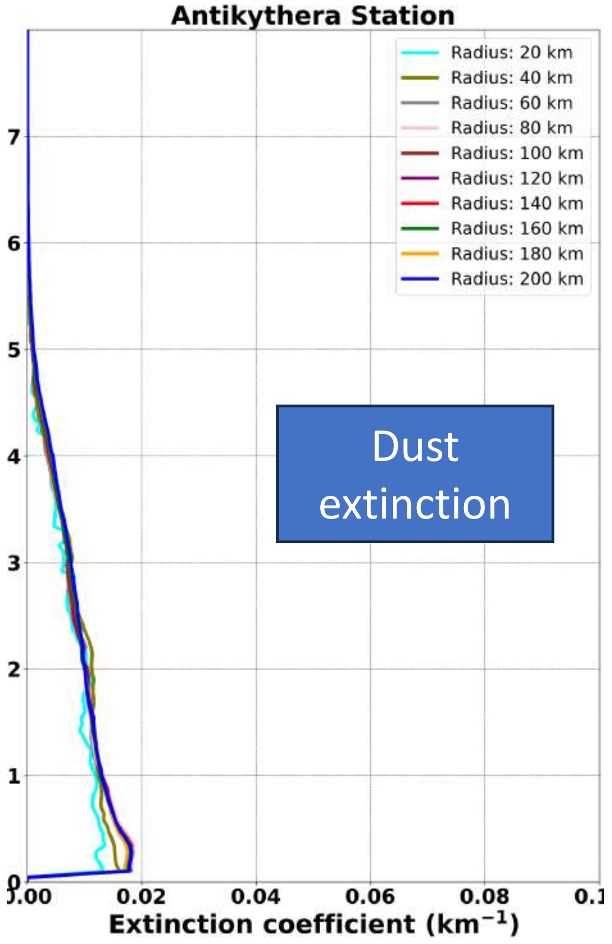
Spatiotemporal aerosol representativeness

Concentric cycles of 20-200 km radius with increment 20 km around the ground-based lidar station of PANGEA



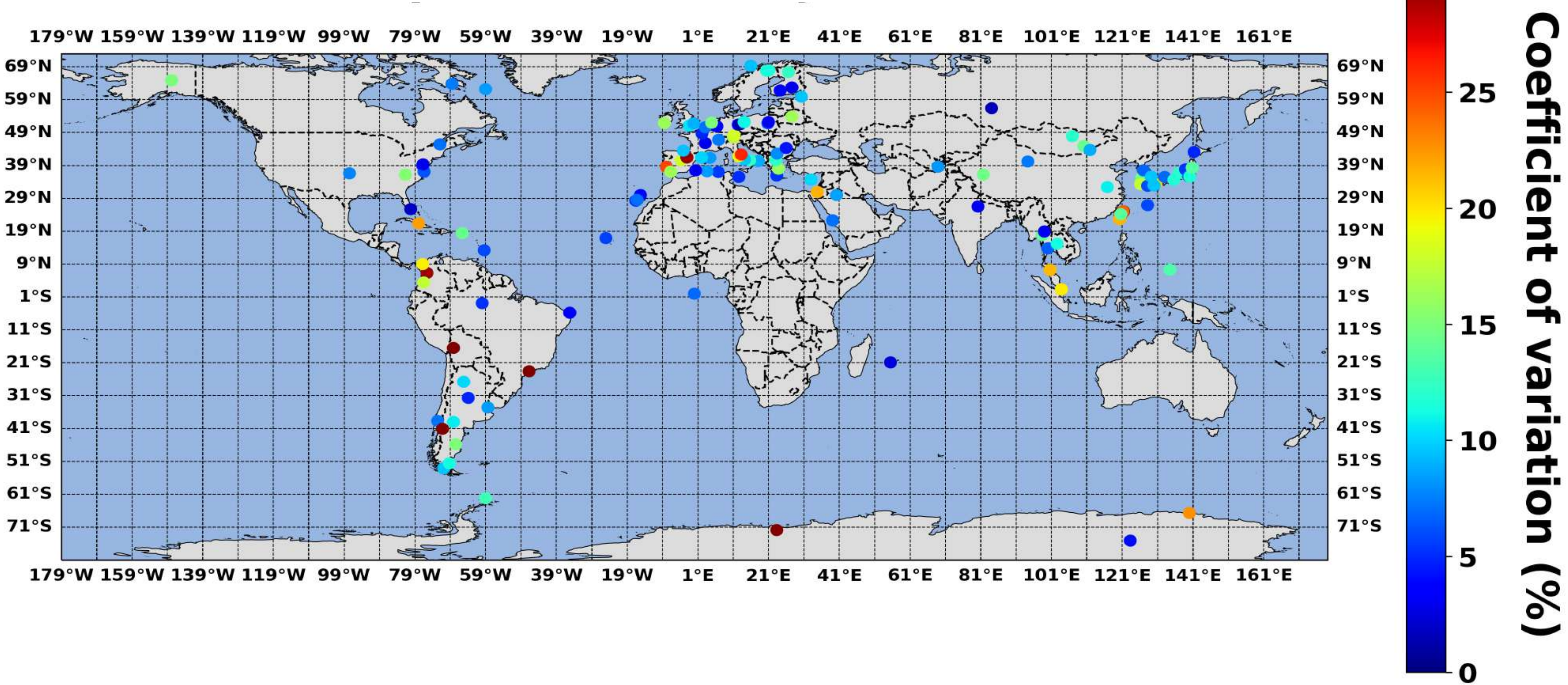
Average re-gridded CALIPSO profiles within the circles [**2006 – 2021**]





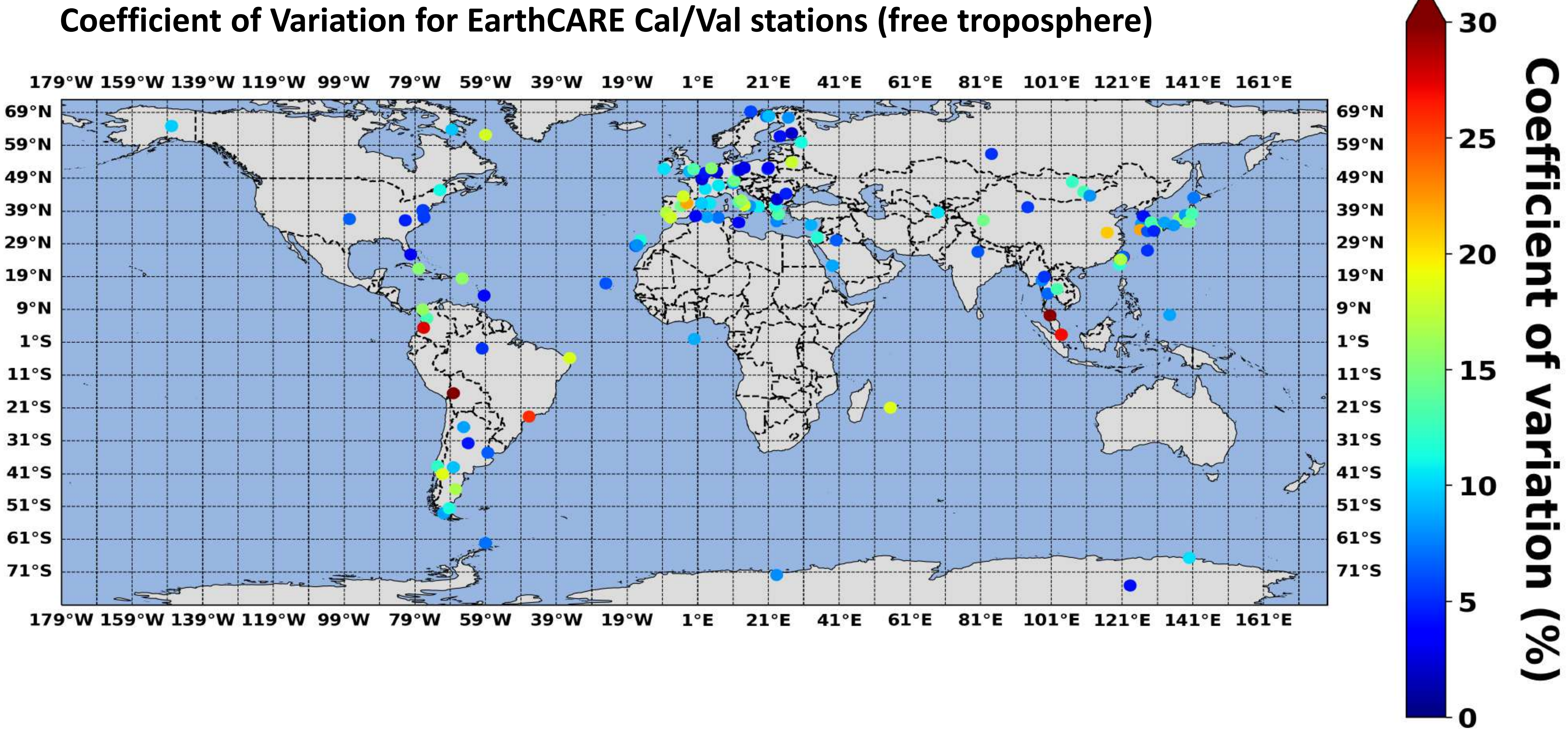
CVs for EarthCARE Cal/Val ground-based lidar stations

Coefficient of Variation for EarthCARE Cal/Val stations



CVs for EarthCARE Cal/Val ground-based lidar stations

Coefficient of Variation for EarthCARE Cal/Val stations (free troposphere)



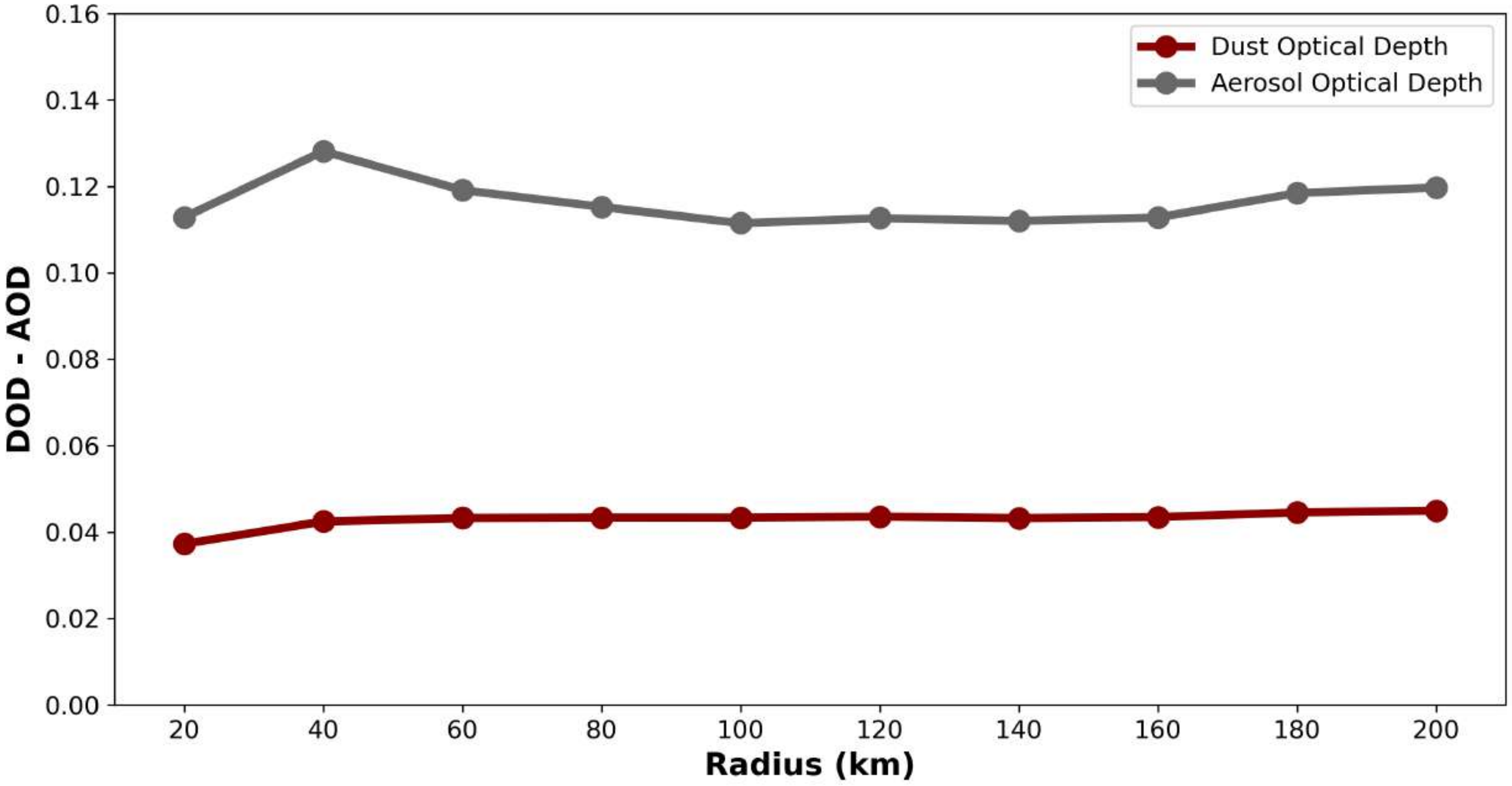
Concluding remarks

- The ACPV targeted studies are ongoing and will be concluded and delivered within the next months in the framework of the ESA activity
- Suborbital-to-orbital transformation tools are under preparation
- Studies and tools along with guidelines for the validation of aerosol and cloud profiles will be consolidated and delivered to the Cal/Val teams by Q1 of 2024 and to CEOS by the end of 2024
- The ACPV community effort is ongoing and remains open to new members!

Thank you for your attention

Spatiotemporal aerosol representativeness

Mean AOD & DOD for different radii around PANGEA



Coefficient of variation (CV)

CV is a measure of the aerosol spatial variability around a monitoring station, defined as the **ratio of the standard deviation to the AOD mean** (Anderson et al., 2003; Shinozuka and Redemann, 2011).

$$CV = \frac{Sd_{AOD}}{M_{AOD}} \times 100\%$$

For example, the CV for PANGEA is ~4% which is very low and as such we assume that the station can be used for several overpasses in the range of 200 km.

Spatiotemporal aerosol representativeness

Impact of sampling:

Total number of CALIPSO profiles for each month and year from 2006 to 2021 and for different radius