



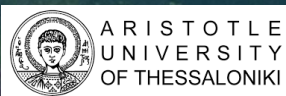
EarthCARE 2026 Science and Validation workshop

8–12 June 2026 | Rhodes House | Oxford, UK

Radiative Closure Experiments for EarthCARE Validation (RACE-ECV): Second Intensive Measurement Campaign for Spectral Radiation and Aerosol Properties

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RACE-ECV 1st campaign spring 2025

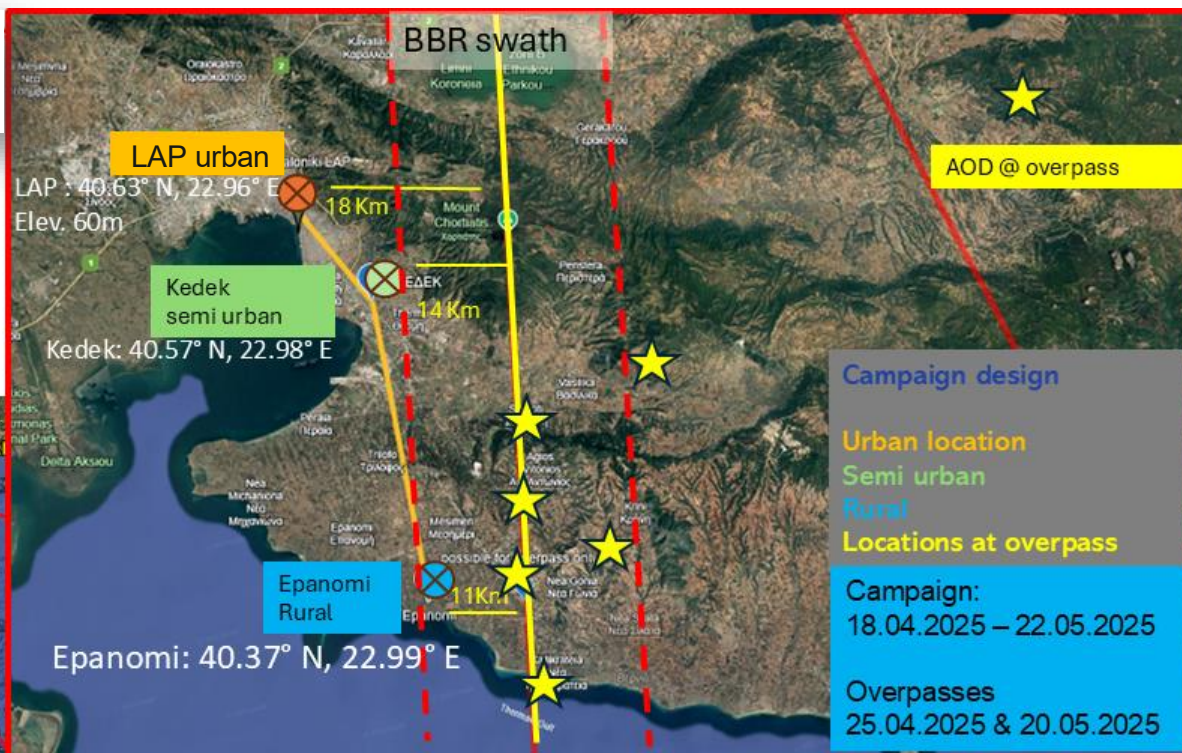


RACE-ECV

Radiation closure experiments for EarthCARE validation



PMOD/World Radiation Center, Switzerland
EVID 44, Swiss funded project (12.2024, 12.2026)



Objectives

- **Directly validate EarthCARE products** related with total column aerosol and cloud optical thickness and aerosol profiles
- **Perform radiative closure studies**
- **Provide a high-quality measurement dataset** consisting of aerosol optical properties and spectral solar irradiance, for science studies and CERTAINTY project

pmoD wrc



University of Zurich



ARISTOTLE UNIVERSITY OF THESSALONIKI



Remote sensing of Aerosols, Clouds and Trace gases



UNIVERSITY OF PATRAS
ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΩΝ



Universidad de Valladolid



ERATOSTHENES 11
CENTRE OF EXCELLENCE



- Preparatory for the main campaign 2026
- Permanent site: LAP + 2 additional sites
- Instrumentation: next slide
- + hand-held photometers (★ stars on the map)
- 2 overpasses

Instrumentation



Urban location (LAP)

Spectral Aerosol columnar properties (AERONET)
Solar spectral measurements (total, diffuse: 300-2500nm)
Broadband solar measurement (SW, total, diffuse, direct)
all-sky camera

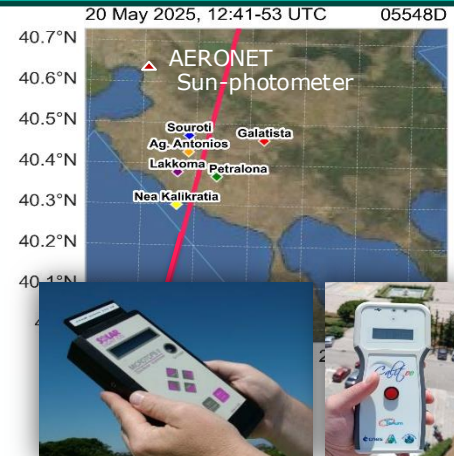
Lidar system Thelisis (3+2+depol) aerosol profiles
Air quality/ trace gases (Max Doas, FTIR, Pandora)



**+hand-held photometers
around the overpass**

Semi Urban (Kedek)

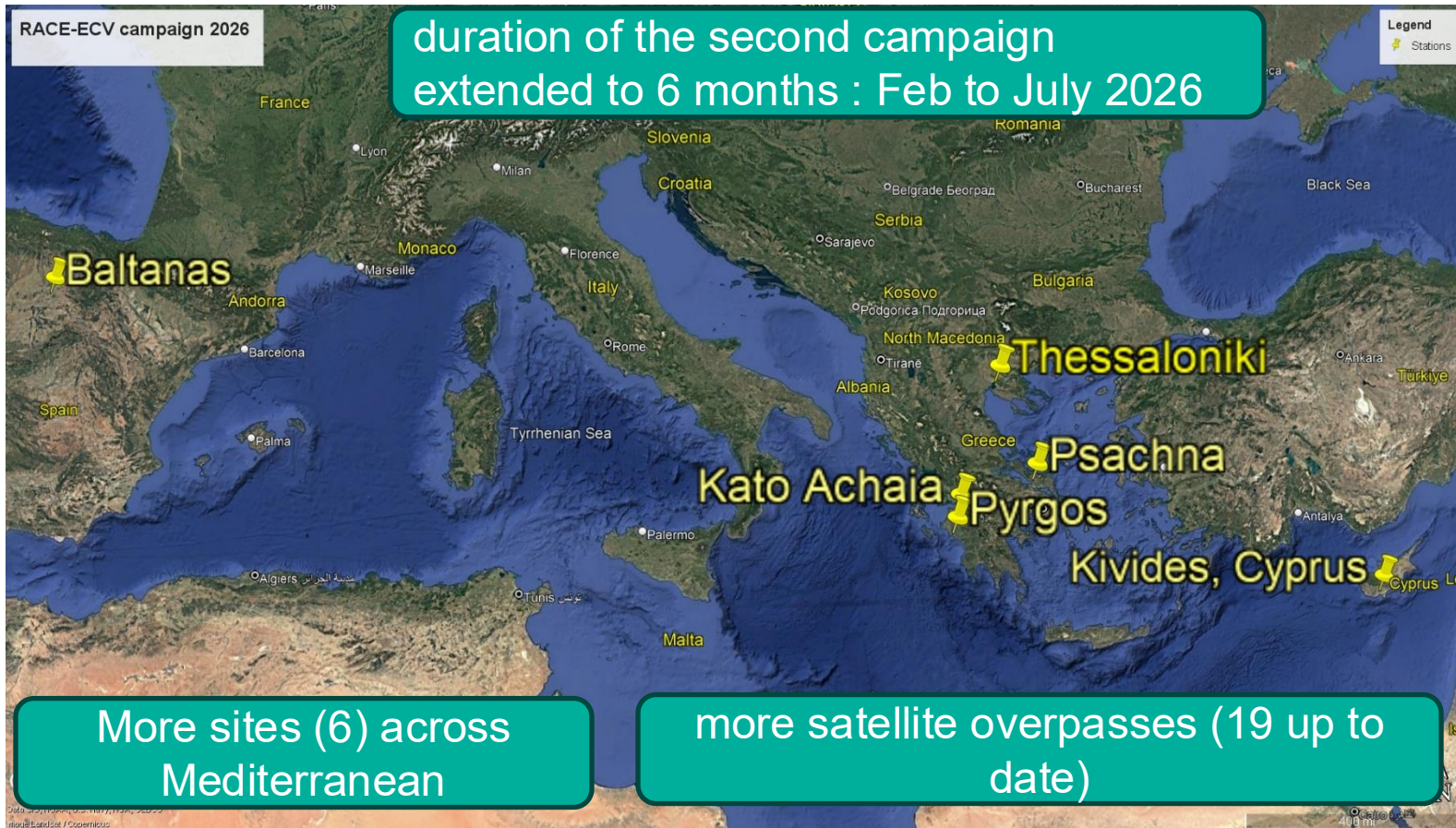
Spectral Aerosol columnar properties (PFR-GAW Network)
Solar spectral measurements (total, diffuse: 300-2500nm)
Broadband solar measurement (SW, total, diffuse, direct)
all-sky camera



Rural location (Epanomi)

Spectral Aerosol columnar properties (PFR-GAW Network)
Solar spectral measurements (total, diffuse: 300-1000nm)
Broadband solar measurement (SW, total, diffuse, direct)
all-sky camera

RACE-ECV 2nd campaign 2026



RACE-ECV

Radiation closure experiments for EarthCARE validation



**PMOD/World Radiation Center,
Switzerland**

EVID 44, Swiss funded project (12.2024,
12.2026)

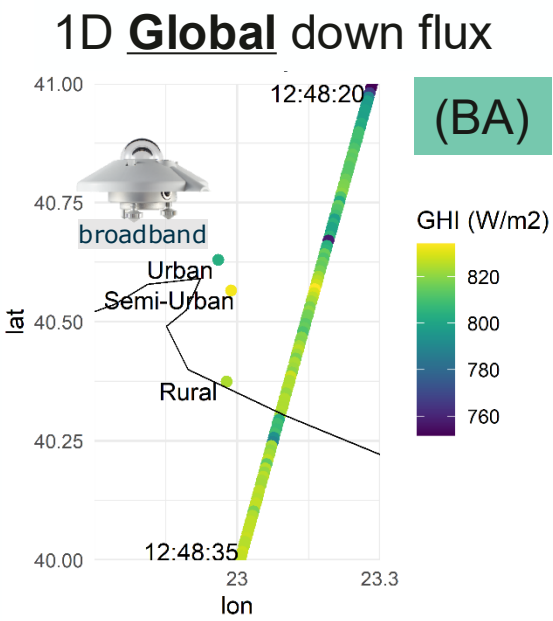
- **All sites:** photometers and broadband solar radiation measurements -> direct validation of *EarthCARE* aerosol and cloud total column optical properties and surface radiation products; radiative closure studies
- **Selected sites:** additional instrumentation including among others spectral solar radiation instruments, all-sky cameras, and lidar systems -> aiming for validation of *EarthCARE* surface radiation products and high-level synergistic products; radiative closure studies at spectral level; 3D cloud reconstruction



Validation of surface irradiance products (L2b ACM_RT)

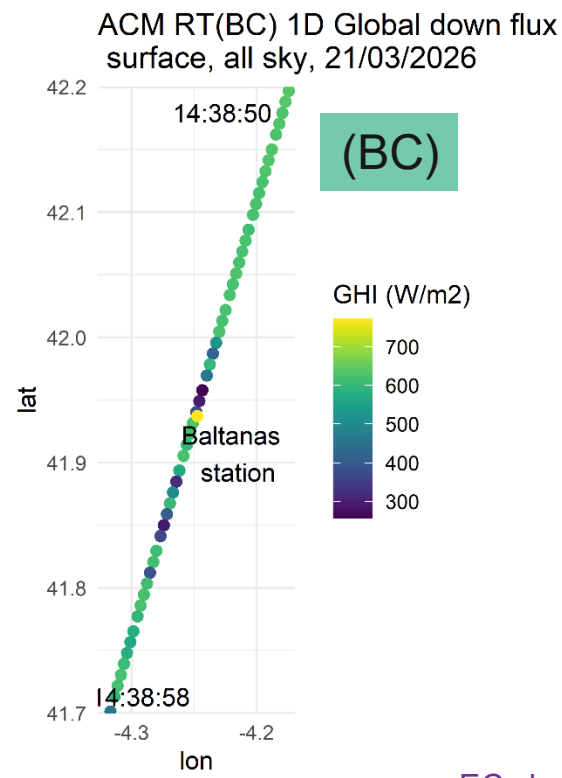


1st campaign -1 overpass available – 20/05/2025

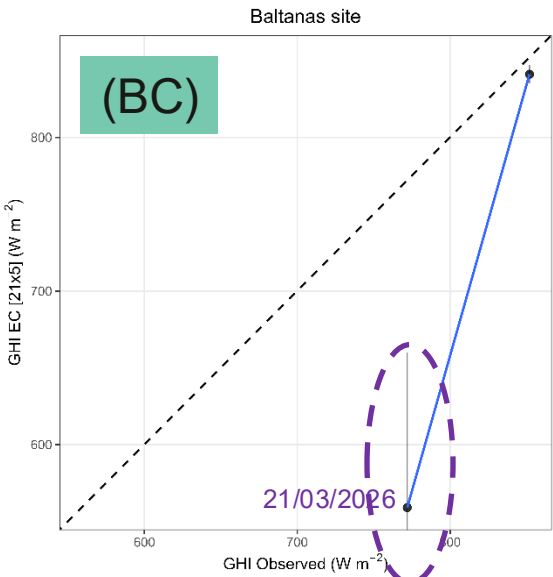


- good agreement: differences below 5%
- Better agreement with averages (3x3) above stations

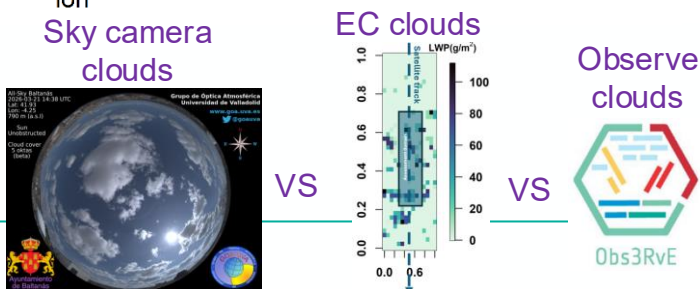
2nd campaign - Ongoing



Statistics with the rest of the overpasses (ongoing)



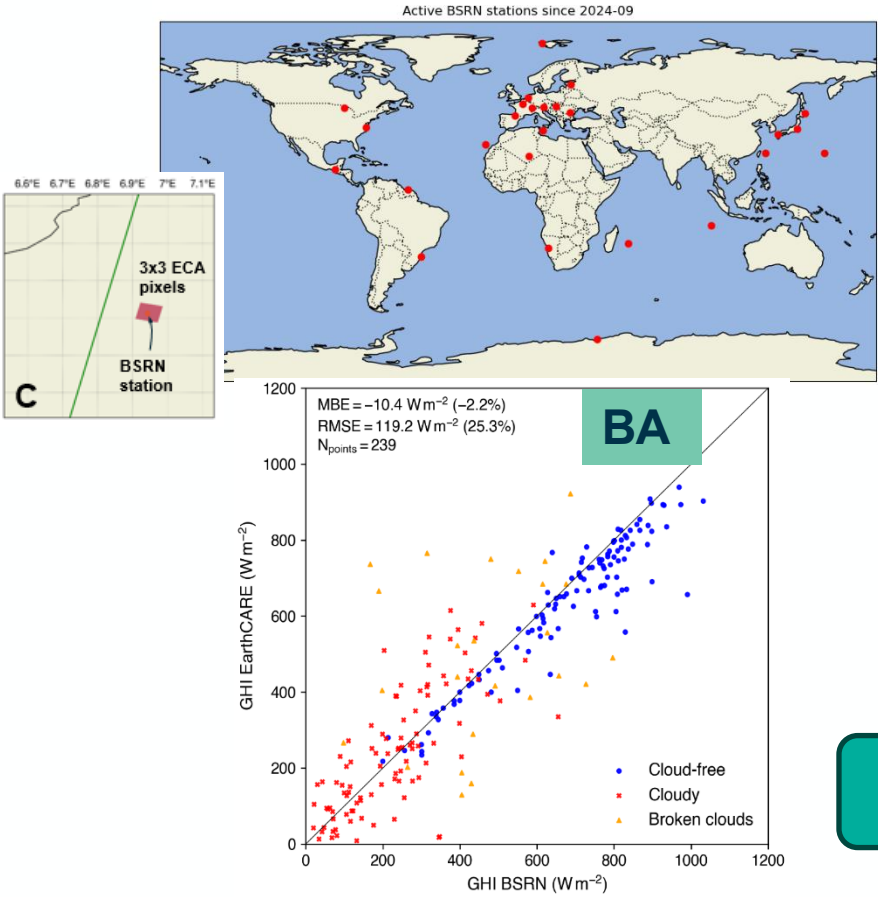
Ongoing analysis
21/03/2026 case



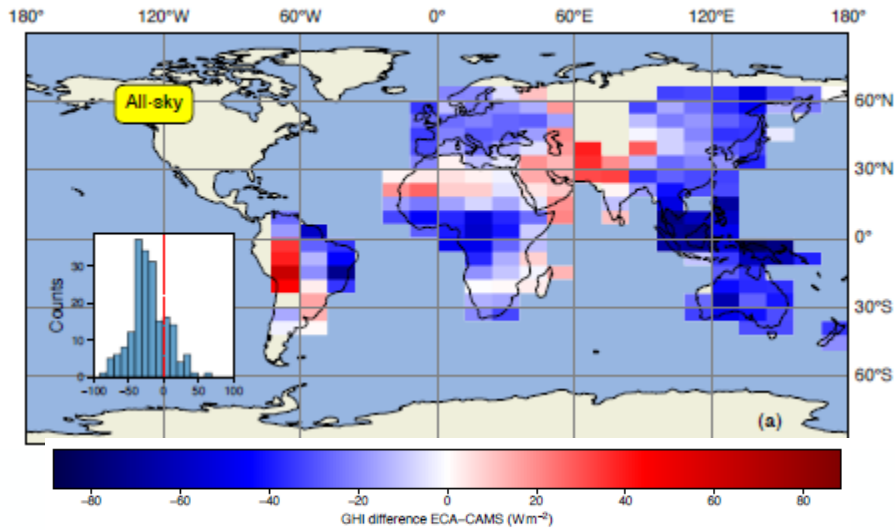
Validation of surface irradiance products (L2b ACM_RT) in a global scale



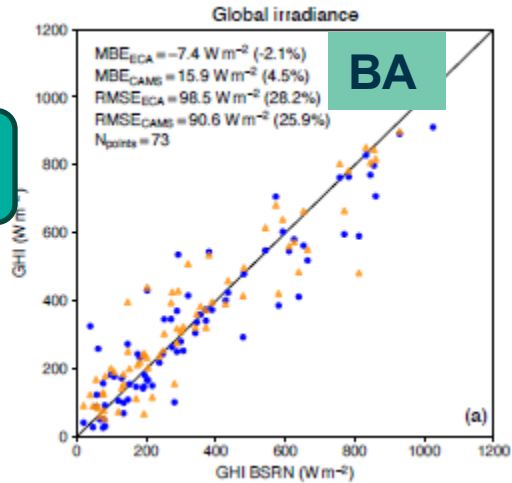
Using ground-based observations by **BSRN**



Intercompare with modelled data from **CAMS** radiation service



ACM_RT slight underestimates global horizontal irradiance (GHI)



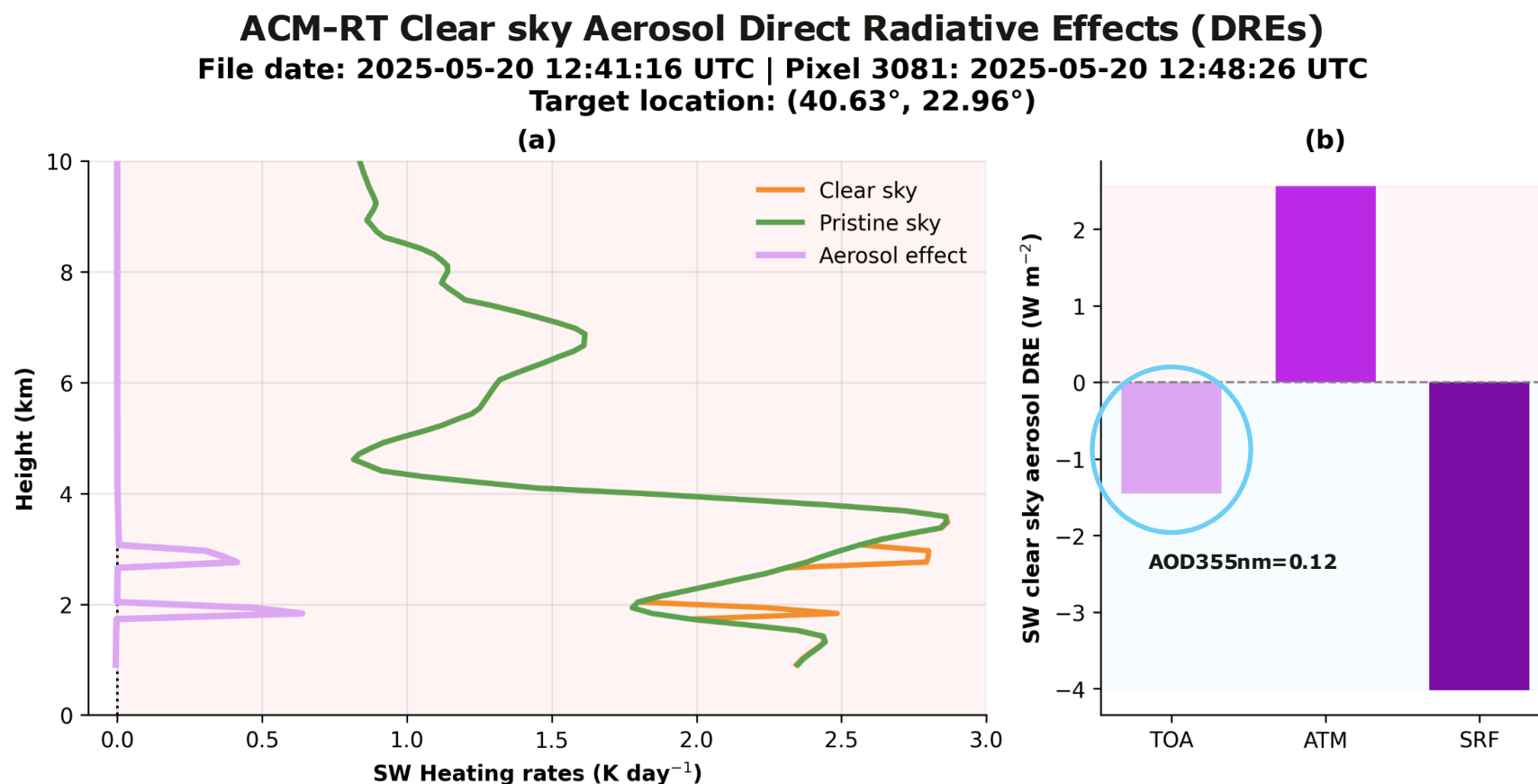
See poster P070
Gschwind, Papachristopoulou, et al.

Gschwind, et al. under preparation

Science exploitation of ACM_RT



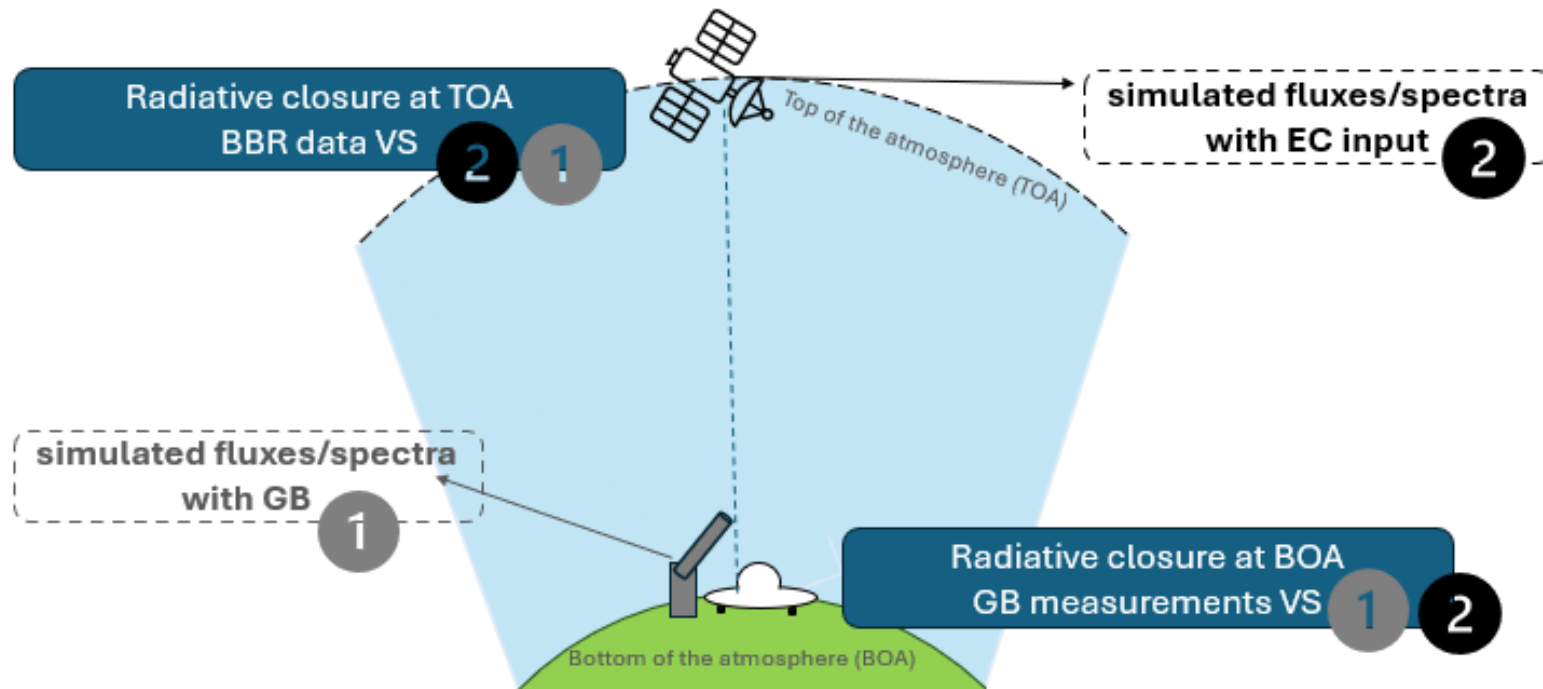
- Accurate irradiance estimates are essential to accurately calculate **aerosol** and **cloud radiative effects**.
- Example:** clear sky aerosol direct radiative effects (DREs) and additional heating rates calculation using ACM_RT product for the campaign location for 20.05.2025.



Radiative closure experiments



1st campaign: 20 May 2025 overpass (LAP station 18 km from the EC overpass)



use **spectral solar radiation observations** ->

to **assess the aerosol and cloud products in the EarthCARE (EC) ACM_COM product** :

L2a composite: COM
and

L2b multi-sensor synergy: CAP

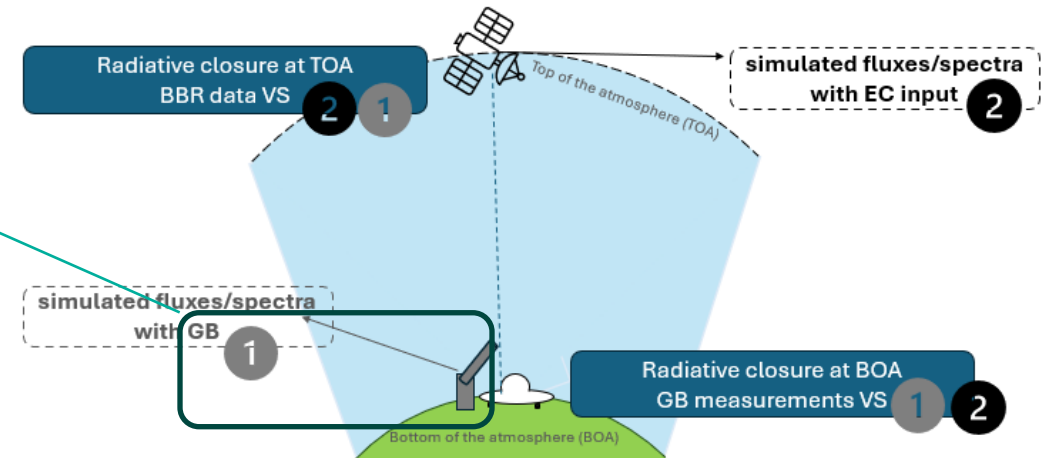
(CAP VS COM, baseline comparisons BA, AC)

Radiative closure experiments



1st campaign: 20 May 2025 overpass (LAP station 18 km from the EC overpass)

Mostly a **clear sky day**
(light cirrus clouds cover around the overpass)



and **low aerosol load** **AOD355nm=0.12**
(BA baseline VS 0.17 for GB observations)

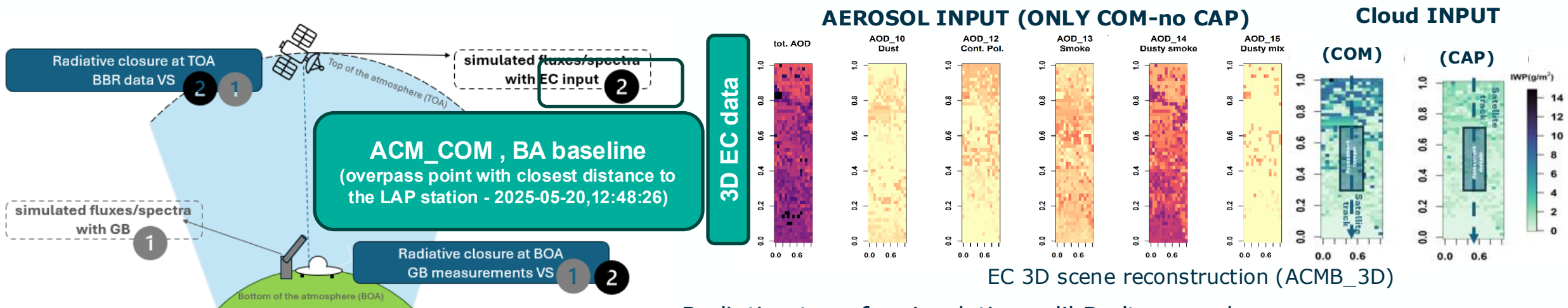
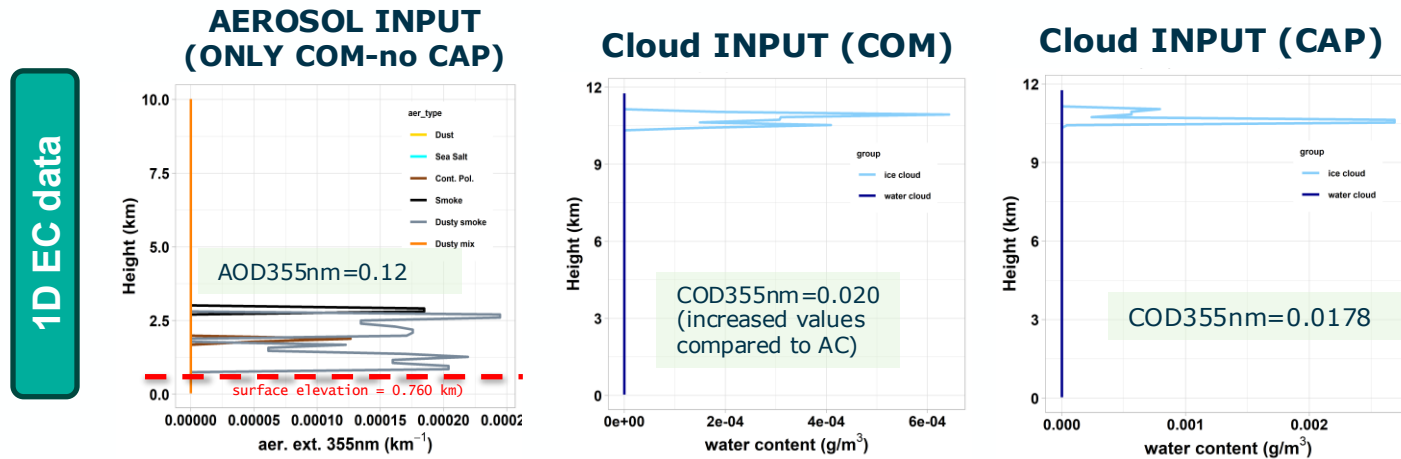
Available:

- **photometer** (CIMEL) aerosol products,
- **Lidar** for aerosol profile

Radiative transfer simulations: libRadtran package

Radiative closure experiments

1st campaign: 20 May 2025 overpass (LAP station 18 km from the EC overpass)



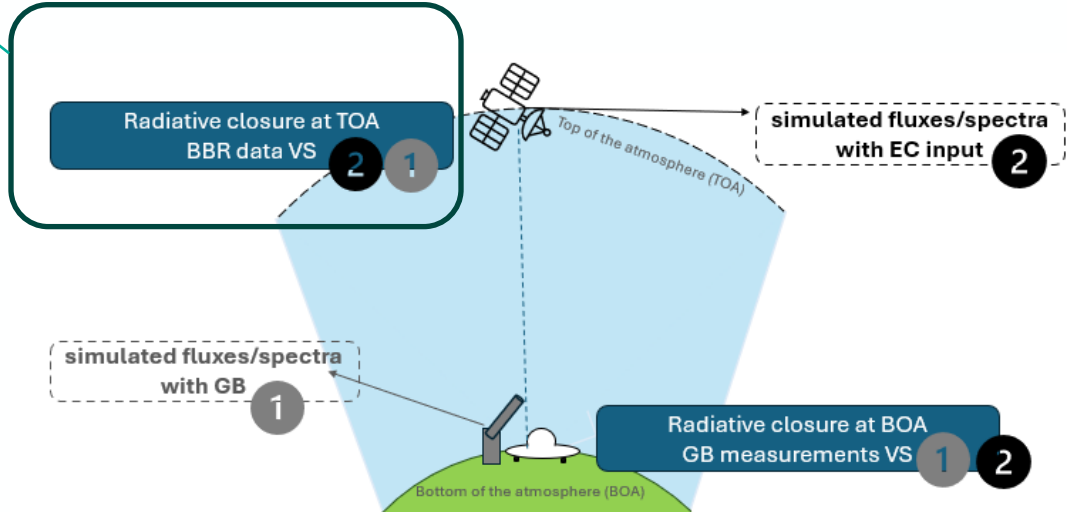
Radiative transfer simulations: libRadtran package

Radiative closure experiments

1st campaign: 20 May 2025 overpass (LAP station 18 km from the EC overpass)

Radiative closure at TOA:

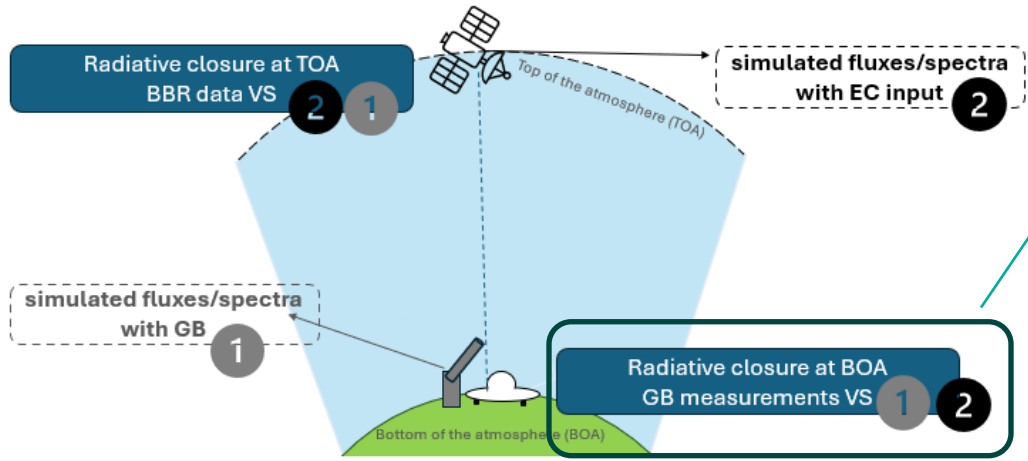
SW upwards flux (W/m ²) estimates at TOA VS <u>BBR</u> (<u>BMA_FLX</u> BA baseline)	ACM_RT BA baseline			RT GB input	RT 1D ACM_COM BA (COM)		RT 3D ACM_COM BA (COM)
	1pixel closest	5pixels (+/-2)	21x5 (SCA)				
MBE (W m ⁻²)	−4.3	−0.6	4.9	−17.6	−0.2		5.8
rMBE (%)	−2.6	−0.4	3.0	−10.6	−0.1		3.5



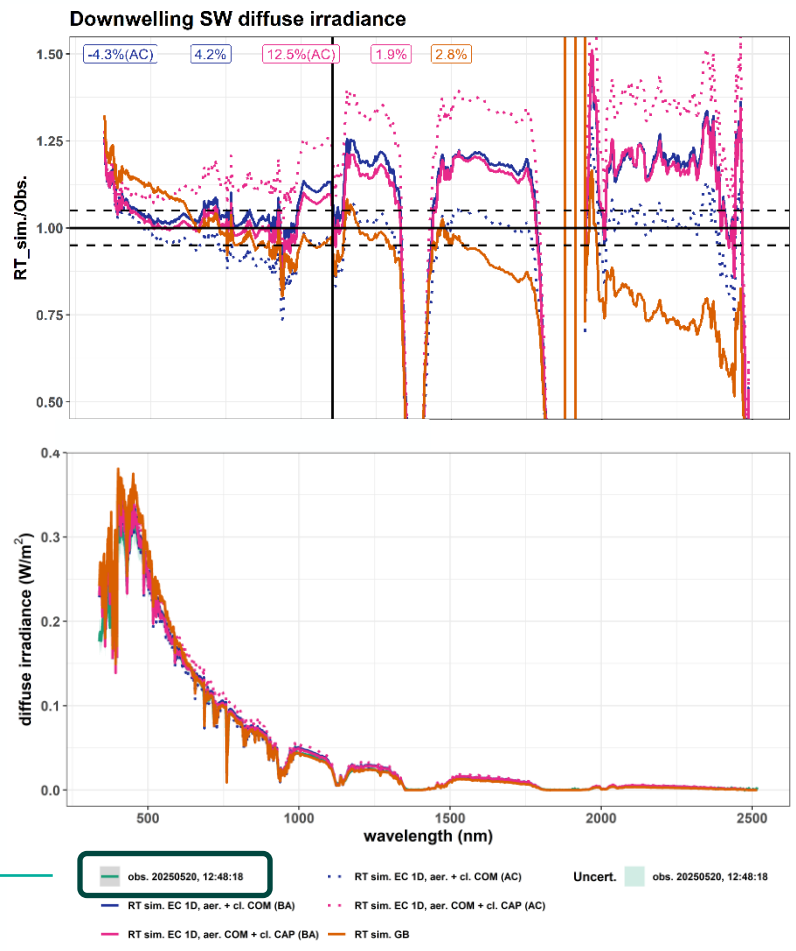
Radiative closure experiments



1st campaign: 20 May 2025 overpass (LAP station 18 km from the EC overpass)



Radiative closure at BOA:



- simulations using EarthCARE aerosol and cloud products from the **ACM_COM** reproduce the **measured spectral diffuse irradiance** with accuracy comparable (or better) to that achieved using ground-based inputs.
- **Improved results for BA baseline**

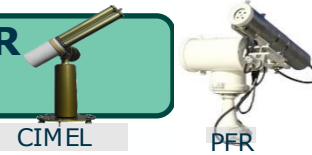
Shortwave (SW 340-2500nm) diffuse spectral obs. (spectroradiometer SVC XHR 1024i)

Validation of MSI-L2 aerosol total column optical properties

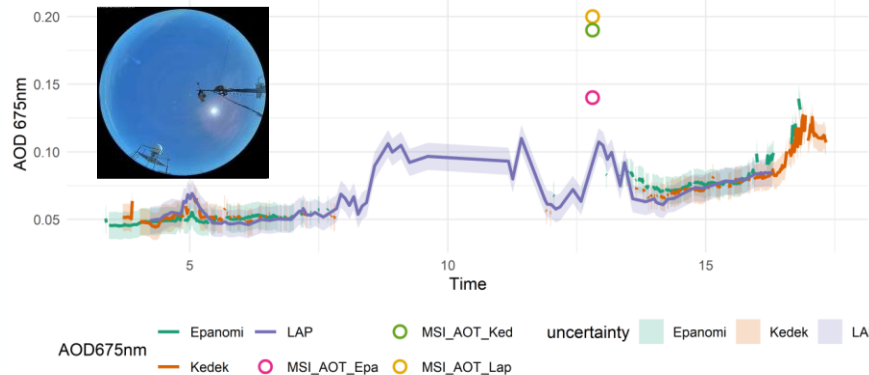


1st campaign

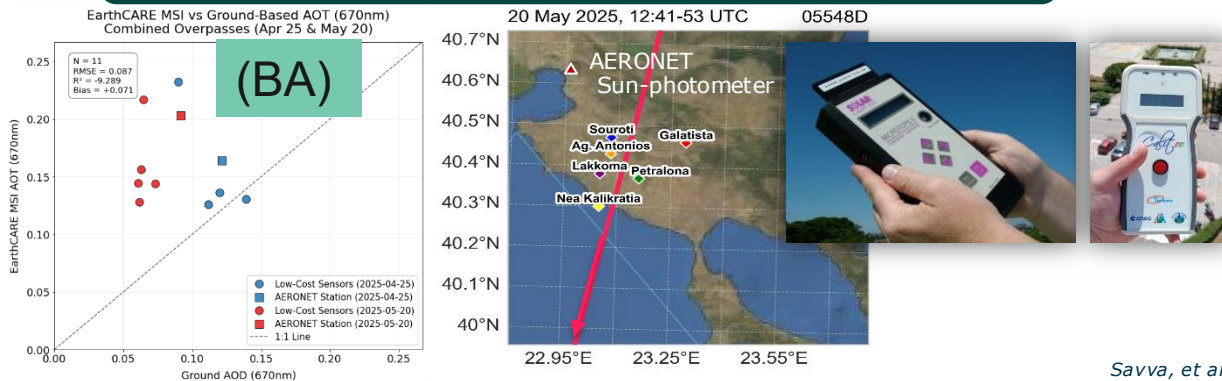
With high precision **CIMEL** and **PFR** photometers



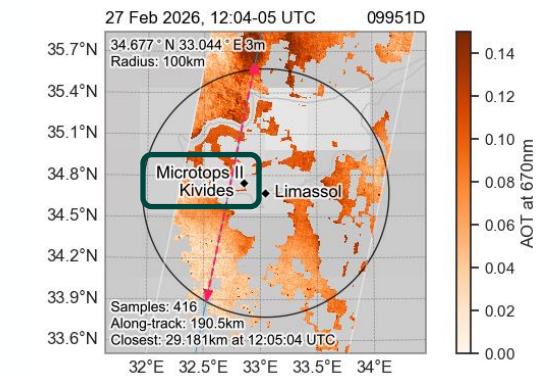
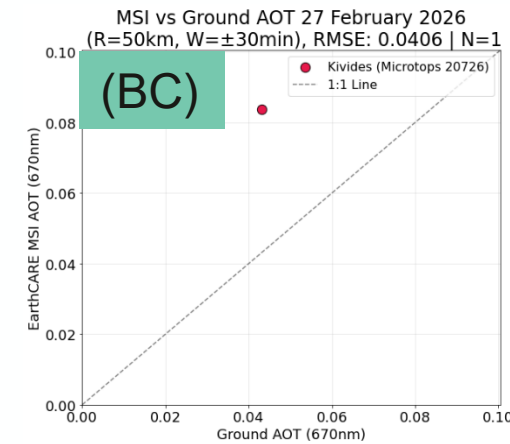
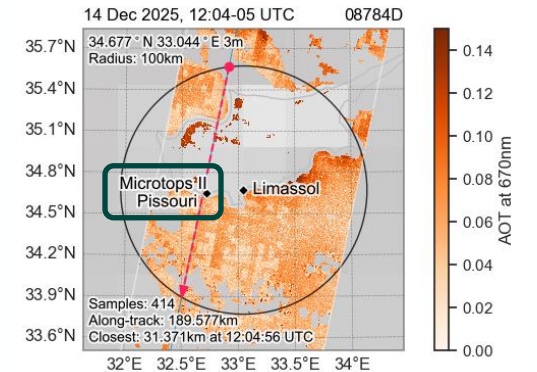
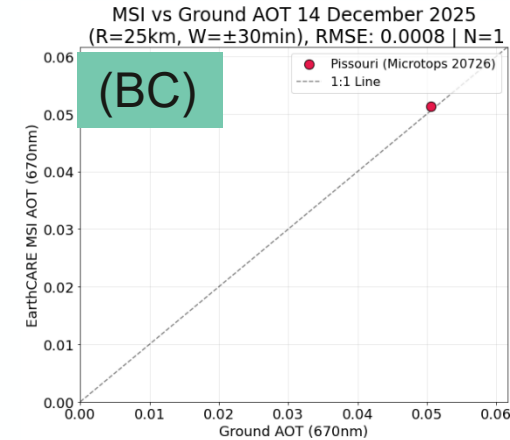
20/05/2025, MSI AOT (BA), radius 50km aver.



With **low-cost hand-held photometers**



2nd campaign – Ongoing



Savva, et al. under preparation

Summary and Future work



- We found a slight underestimation of surface global horizontal irradiance (GHI) in the ACM_RT BA product.
- We demonstrated the value of spectral radiative closure analysis for assessing aerosol and cloud products and for comparing different baseline datasets.
- The use of low-cost photometers represents a trade-off between measurement accuracy (relative to PFR and CIMEL instruments) and the benefits of increased data availability and spatial coverage for satellite aerosol optical thickness (AOT) validation activities.

Future Work:

- Analyze all overpass datasets from the second RACE-ECV campaign (spring – summer 2026)

Thank
you

RACE-ECV
Radiation closure experiments for EarthCARE validation



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(12.2024, 12.2026)

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Confederaziun svizra
Swiss Confederation
Federal Department of Economic Affairs,
Education and Research EAER,
State Secretariat for Education,
Research and Innovation SERI

**CERTAINTY**
CLOUD-AEROSOL INTERACTIONS
& THEIR IMPACTS IN THE EARTH SYSTEM

