Radiation closure experiments for the validation of EarthCARE, Stelios Kazadzis + collaborators

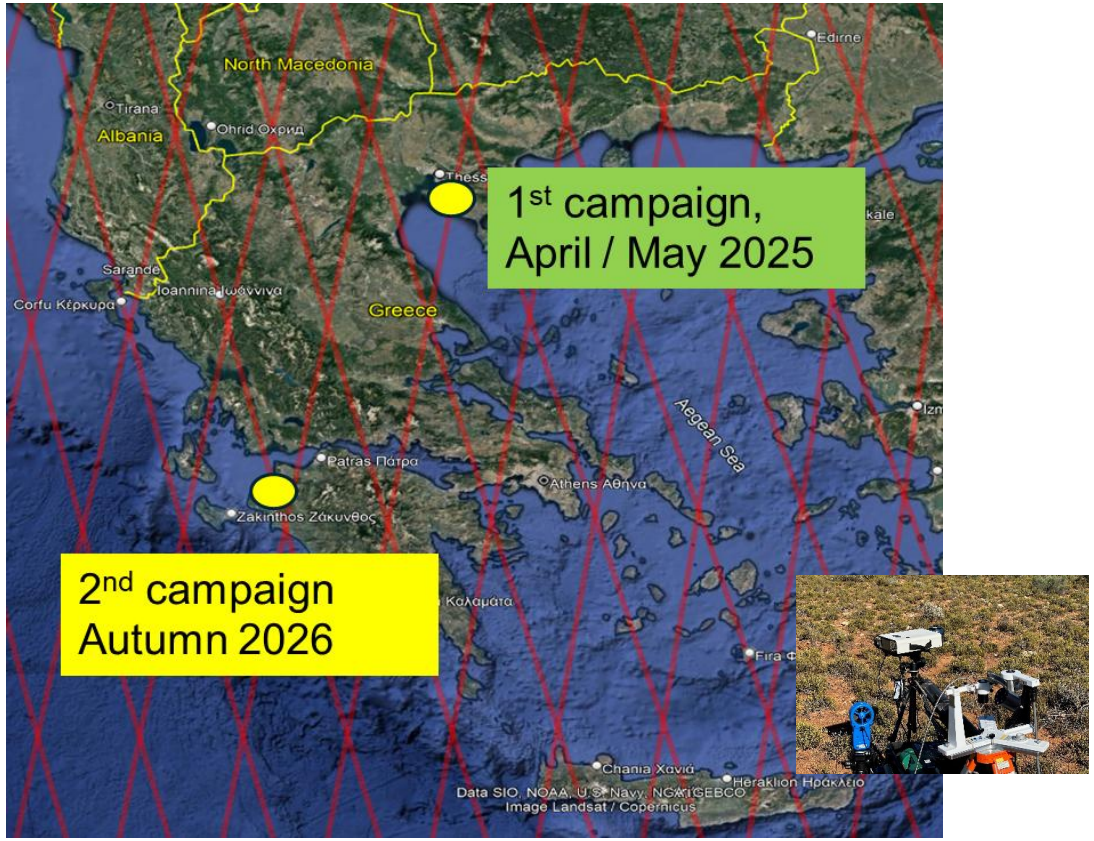
PMOD/World Radiation Center, Switzerland

EVID 44, Swiss funded project (12.2024-12.2026)

RACE-ECV
Radiation closure experiments for EarthCARE validation

Swiss participation in two experimental campaigns (Greece) through the proposed RACE-ECV

HARMONIA
International network for harmonization of atmospheric aerosol retrievals from ground based photometers



Radiation closure experiments for the validation of EarthCARE

RACE-ECV
Radiation closure experiments for EarthCARE validation

HARMONIA
International network for harmonization of atmospheric aerosol retrievals from ground based photometers

Participants

pmod wrc

ARISTOTLE UNIVERSITY OF THESSALONIKI

University of Zurich[UZH]

Laboratory of Atmospheric Physics - University of Patras - LapUp

ERATOSTHENES CENTRE OF EXCELLENCE

ReACT
Remote sensing of Aerosols, Clouds and Trace gases

IAASARS

Radiation closure experiments for the validation of EarthCARE

RACE-ECV
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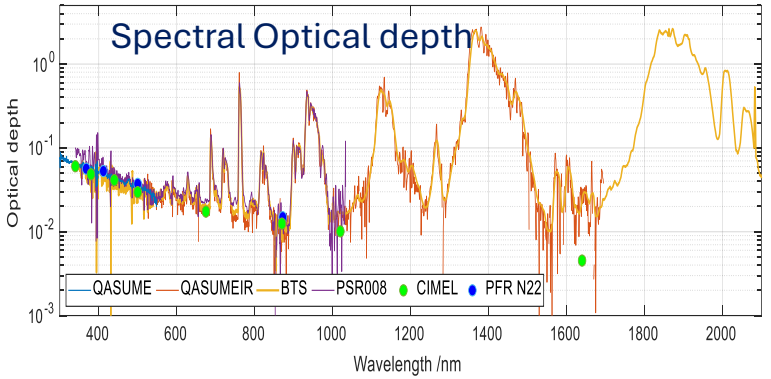
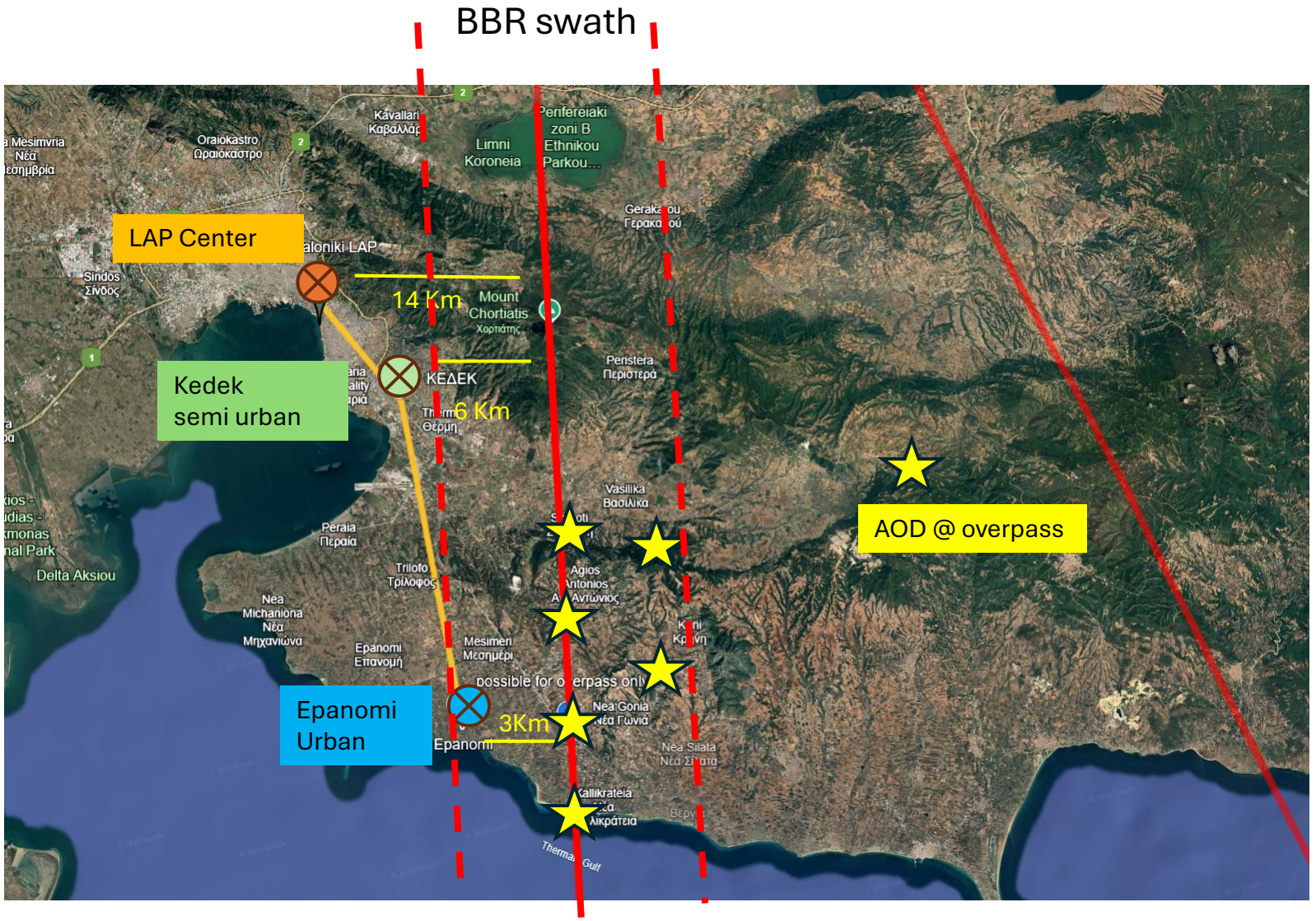


Objectives

- **directly validate EarthCARE products** related with total column multi-wavelength aerosol and cloud optical thickness
- ***perform radiative closure studies*** through intercomparisons with high-quality solar irradiance measurements and Radiative Transfer Model (RTM) simulations
- To ***provide a high quality measurement dataset*** consisting of aerosol optical properties and also spectral solar irradiance, towards various atmospheric studies and EU projects dealing with aerosol-cloud interactions (e.g. CERTAINTY).

Campaign location, Thessaloniki, Greece



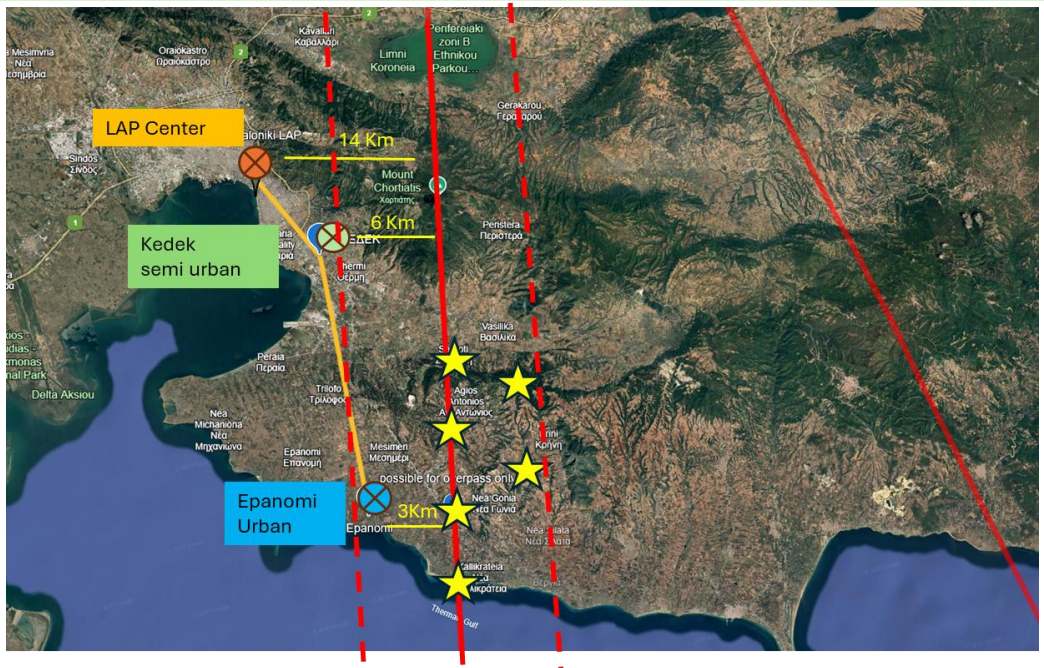
Campaign design

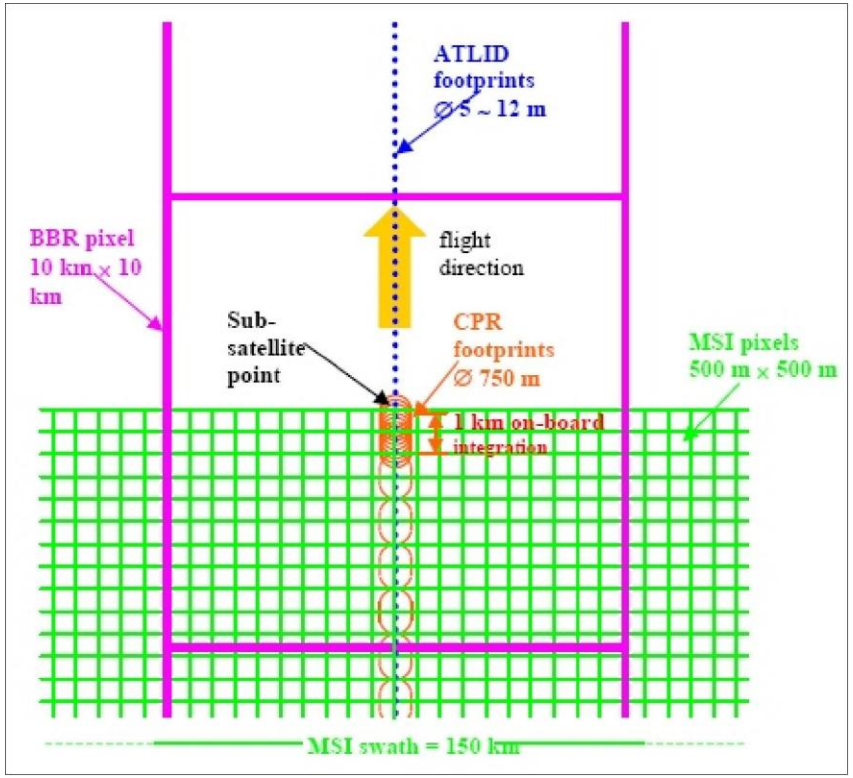
Urban location
Semi urban
Rural
Locations at overpass

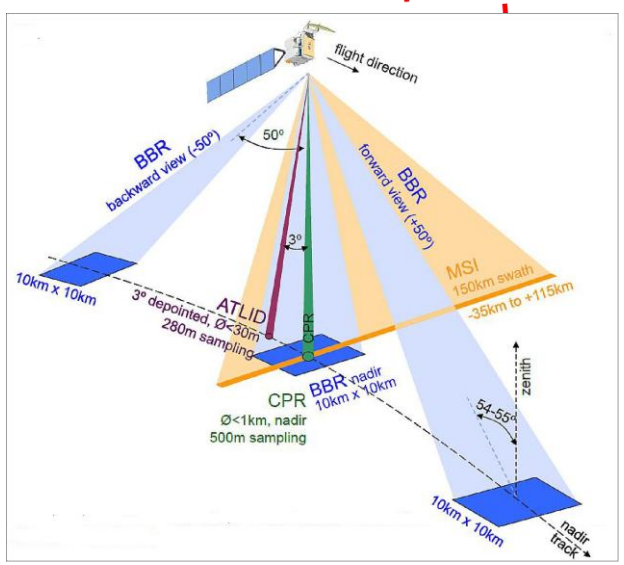
Campaign:
18.04.2025 – 22.05.2025

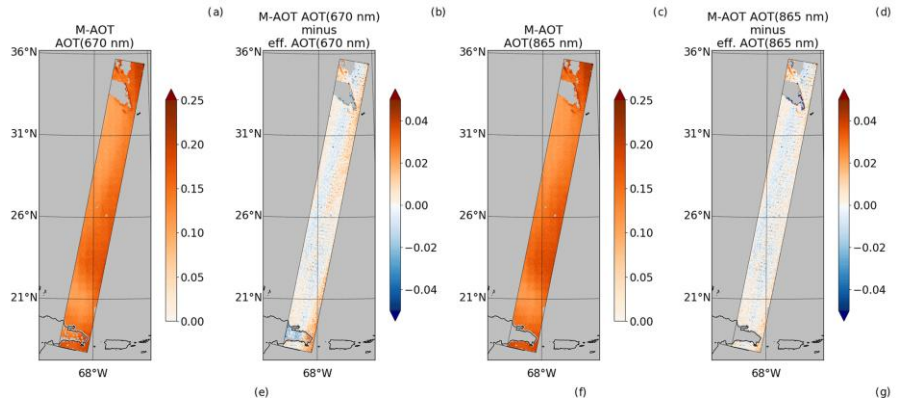
Overpasses:
25.04.2025 & 20.05.2025

Campaign location, Thessaloniki, Greece









MSI

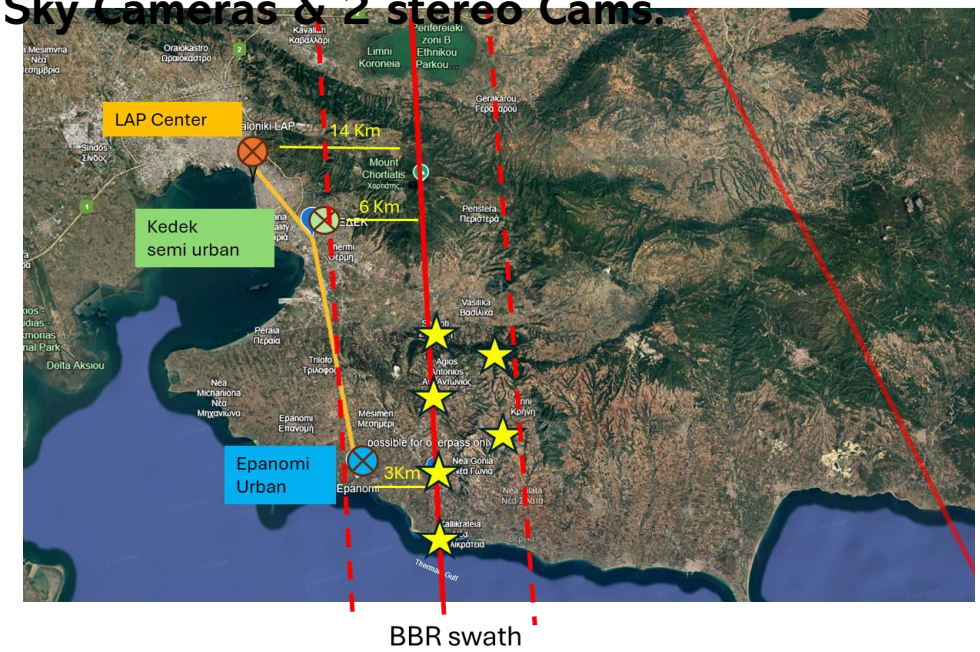
Cloud optical and physical properties retrieval from EarthCARE multi-spectral imager: the M-COP products

Anja Hünerbein ✉, Sebastian Bley, Hartwig Deneke, Jan Fokke Meirink, Gerd-Jan van Zadelhoff, and Andi Walther

Instrumentation

Urban location

Lidar system Thelisis (3+2+depol) aerosols
Spectral Aerosol columnar properties (AERONET)
Solar spectral measurements (total, diffuse: 300-2500nm)
Broadband solar measurement (SW, total, diffuse, direct)
Air quality/ trace gases (Max Doas, FTIR, Pandora)
Sky Cameras & 2 stereo Cams.

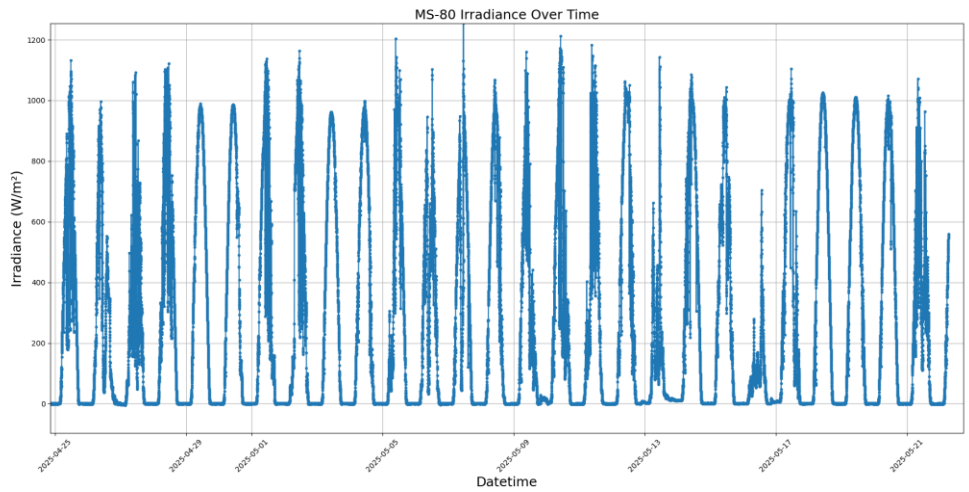


Semi Urban

Spectral Aerosol columnar properties (PFR-GAW Network)
Solar spectral measurements (total, diffuse: 300-2500nm)
Broadband solar measurement (SW, total, diffuse, direct)
Air quality/ trace gases (Max Doas)
Sky Camera

Rural location

Spectral Aerosol columnar properties (PFR-GAW Network)
Solar spectral measurements (total, diffuse: 300-1000nm)
E… …se,
d…
S…



Specific/ technical objectives

RACE-ECV
Radiation closure experiments for EarthCARE validation

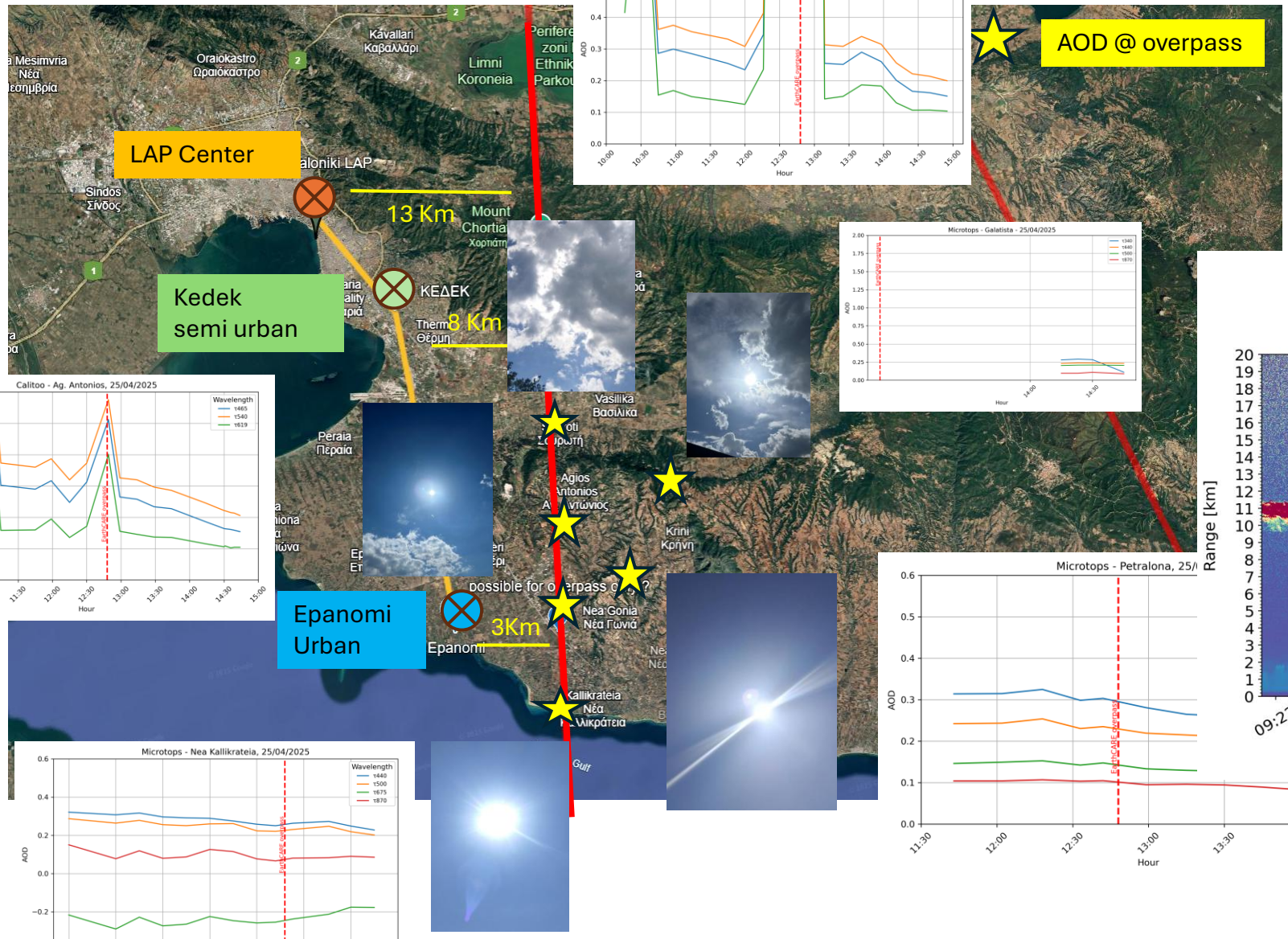
Spatiotemporal uncertainties on validation aspects

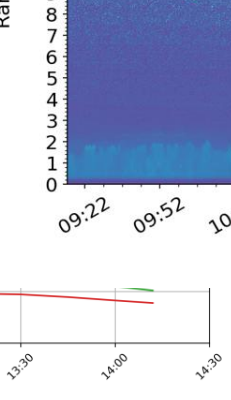
- **Spatiotemporal analysis of Aerosol Optical Depth (AOD) and solar spectral radiation** across all days at the three monitoring sites, with discussion on potential correlations with MSI AOD products, BBR retrievals and Lidar aerosol retrievals from the EarthCARE satellite mission. (**direct validation and rad. closure studies**)

- Investigation of **cloud variability** at the three sites and its influence on both total and spectral surface radiation measurements.
- Utilization of ground-based cloud cameras to reconstruct the **3D cloud structure**, including approaches combining two NASA sky cameras at a single site for stereoscopic 3D cloud modeling.

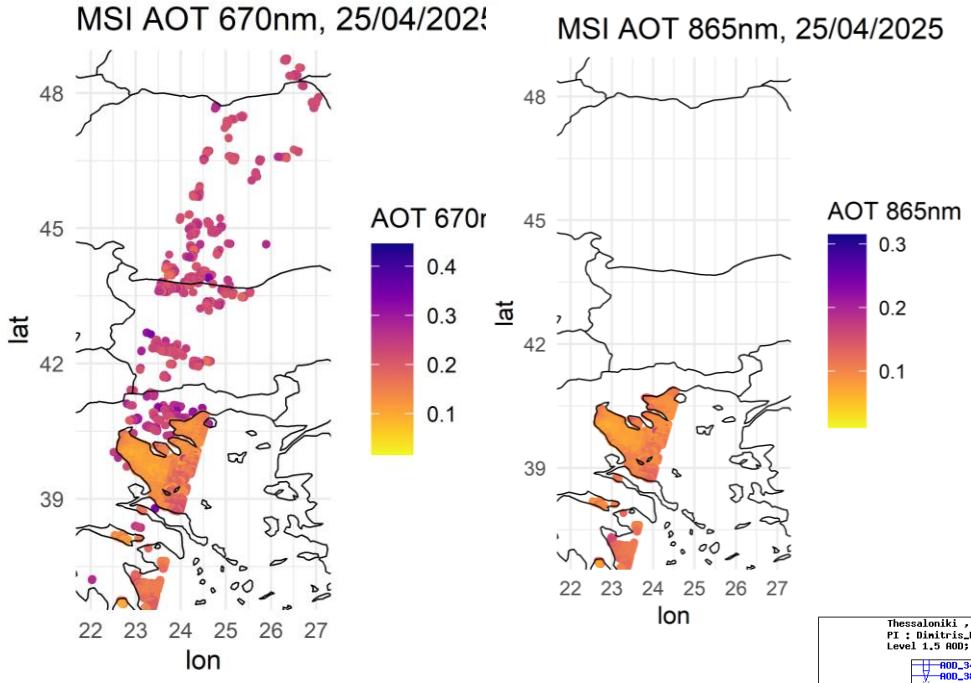
- Comparative analysis of **low-cost sensors**, including their calibration using Standard Transfer Standard Methodology and evaluation of their applicability for overpass observations. Additionally, comparison with LiDAR measurements in terms of accuracy, resolution, and practical deployment.
- Comparison of cloud optical thickness (COT) retrieved from (MSG/MTG) satellite data with COT estimates derived from pyranometer observations at the three sites, and analysis of the resulting impact on radiative fluxes.

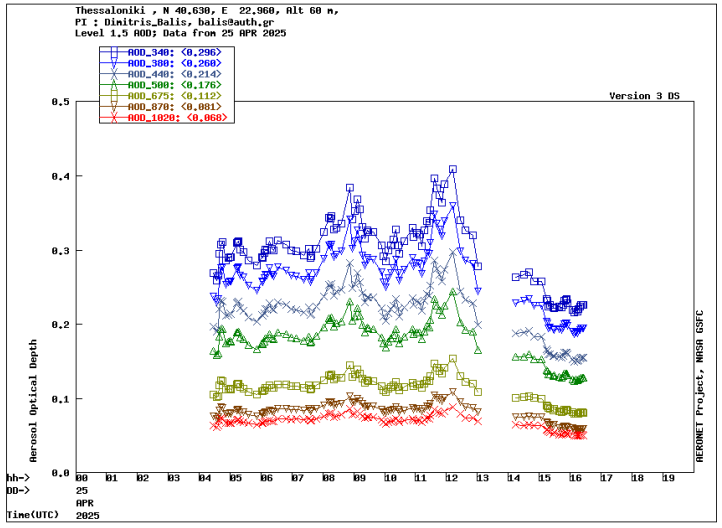
1st overpass





1st overpass





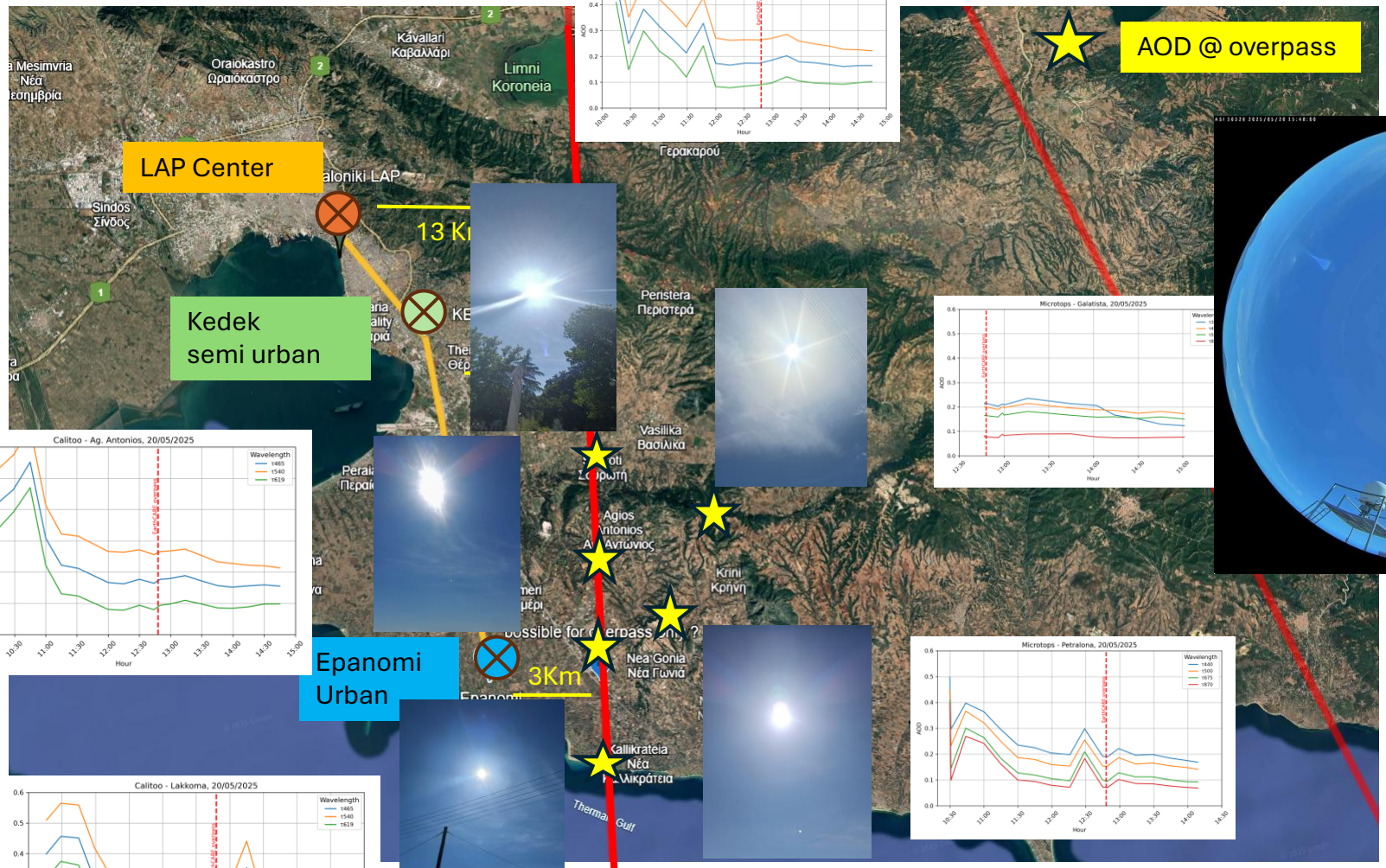
MSI AOT overestimation for AOT 670nm (high uncertainty)

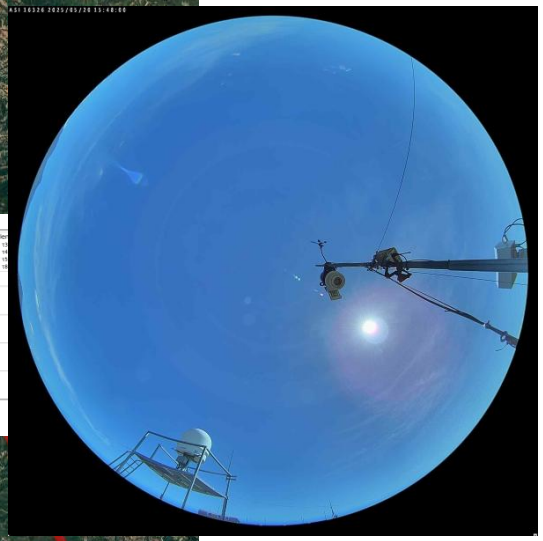
City	
MSI AOT 670nm	**Cimel AOD 675nm**
Mean 0.26 (sd 0.04) +/-0.34!!	0.12

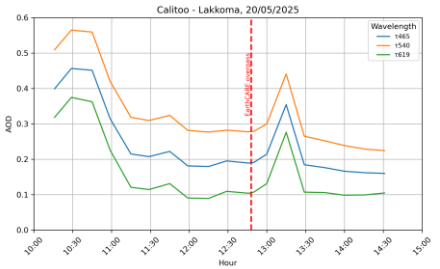
Rural	
MSI AOT 670nm	**PFR AOD 500nm**
Mean 0.13 (sd 0.02) +/-0.02	0.09 overpass 0.11 daily mean
MSI AOT 865nm	**PFR AOD 862nm**
Mean 0.088 (sd 0.006) +/-0.003	0.05 overpass 0.06 daily mean

Semi urban	
MSI AOT 670nm	**PFR AOD 500nm**
Mean 0.26 (sd 0.01) +/-0.34!!	NA overpass 0.20 daily mean
MSI AOT 865nm	**PFR AOD 862nm**
Mean 0.118 (sd 0.007) +/-0.003	NA overpass 0.11 daily mean

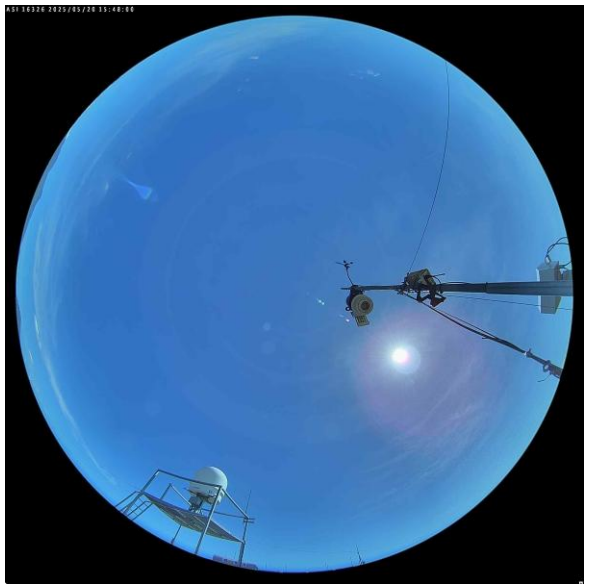
2nd overpass

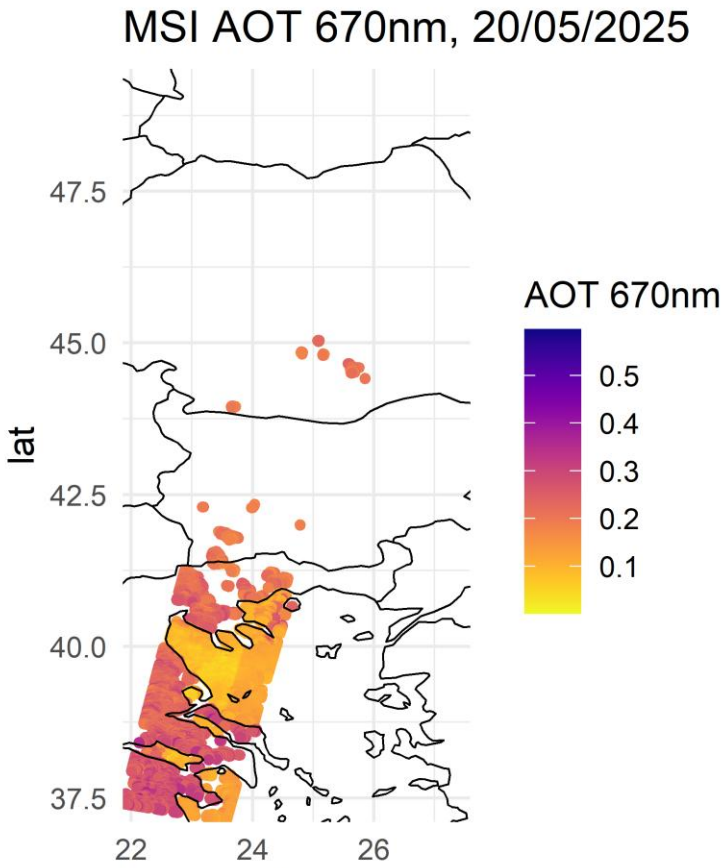


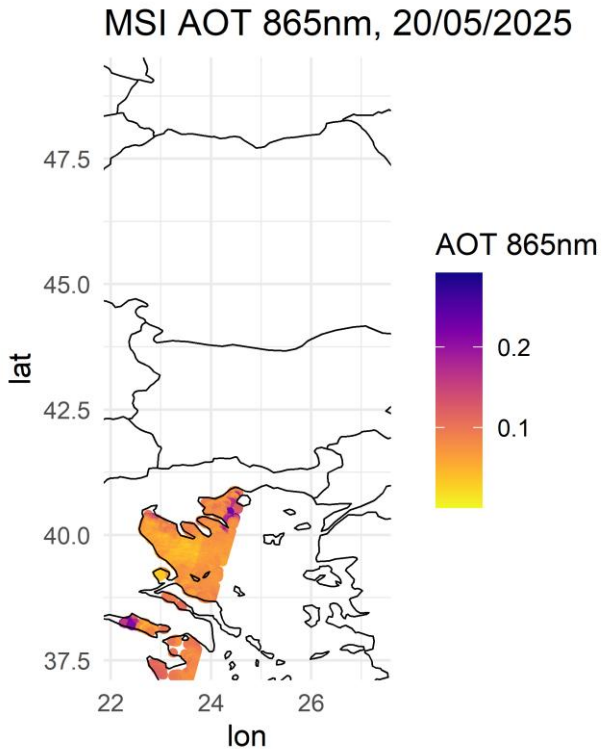




Kedek camera



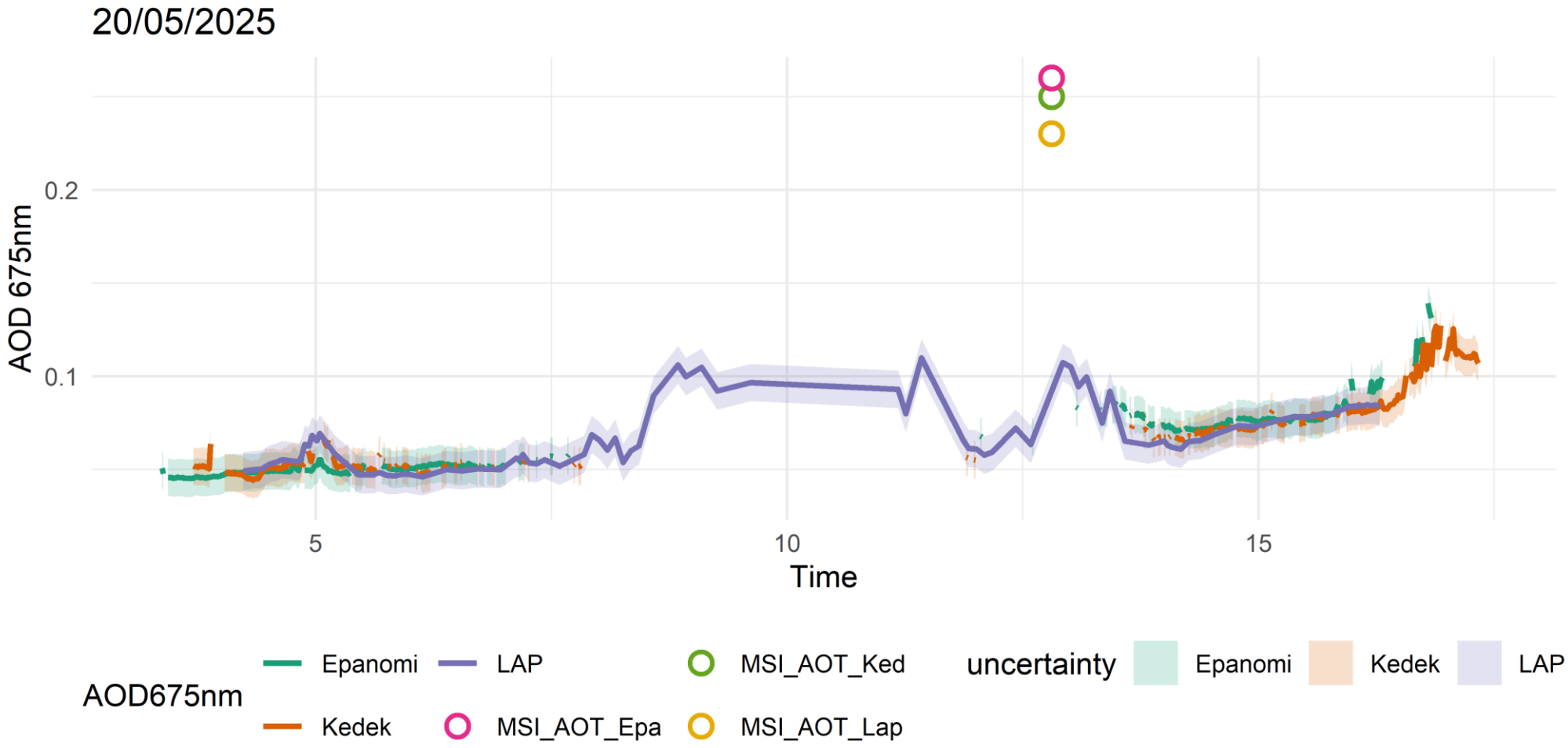




LAP	
MSI AOT 670nm	**Cimel AOD 675nm**
Mean (21x21, N=22) 0.23 (sd 0.03) +/- 0.31!!	0.07 overpass

Kedek		
MSI AOT 670nm	**PFR AOD 500nm**	**PFR AOD 675nm**
Mean (11x11, N=2) 0.25 (sd 0.001) +/-0.31!!	0.11 overpass	0.09 overpass

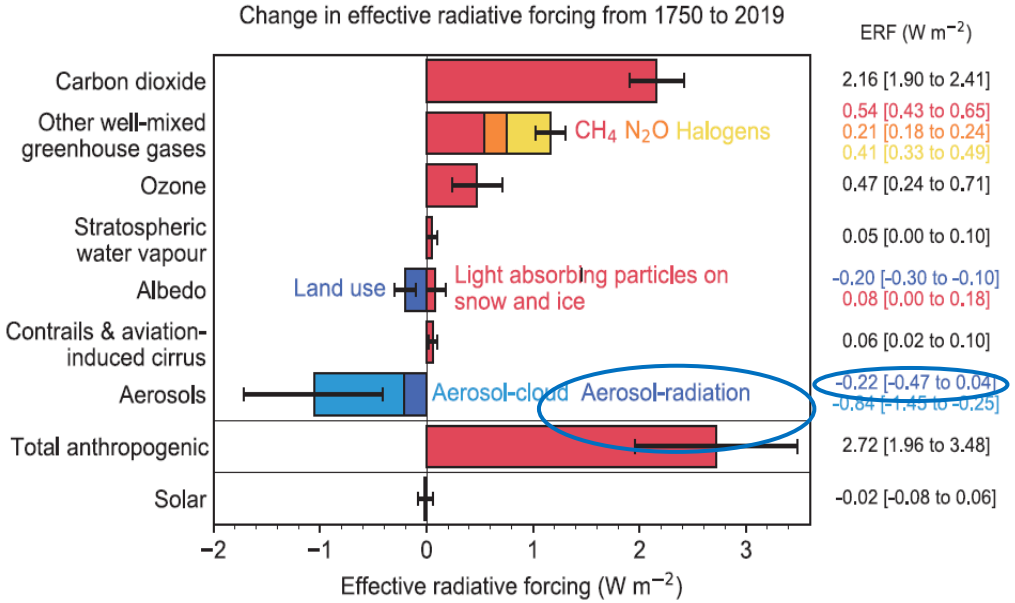
Epanomi		
MSI AOT 670nm	**PFR AOD 500nm**	**PFR AOD 675nm**
Mean (21x21, N=358) 0.26 (sd 0.02) +/- 0.32!!	0.12 overpass	0.08 overpass


20/05/2025
AOD 675nm
0.2
0.1
5
10
15
Time
AOD675nm
Epanomi
LAP
MSI_AOT_Ked
Kedek
MSI_AOT_Epa
MSI_AOT_Lap
uncertainty
Epanomi
Kedek
LAP

Aerosol direct radiative effects (DREs) under realistic 3D cloudy scenes using EarthCARE data

- Accurate estimates of **aerosol radiative effects** are important for better understanding the effects of aerosols on **earth's energy budget**.

- The assessment of aerosol direct radiative effects on cloudy atmospheres (**all-skies aerosol direct radiative effects**) is a difficult task as their properties, vary with altitude, impact atmospheric RT.



IPCC, 2021

Gap:

- **Up to now only 1D** Aerosol DRE estimates (both model and satellite based)

Scientific questions:

- Do the Aerosol DREs differ between 1D and 3D radiative transfer estimates?

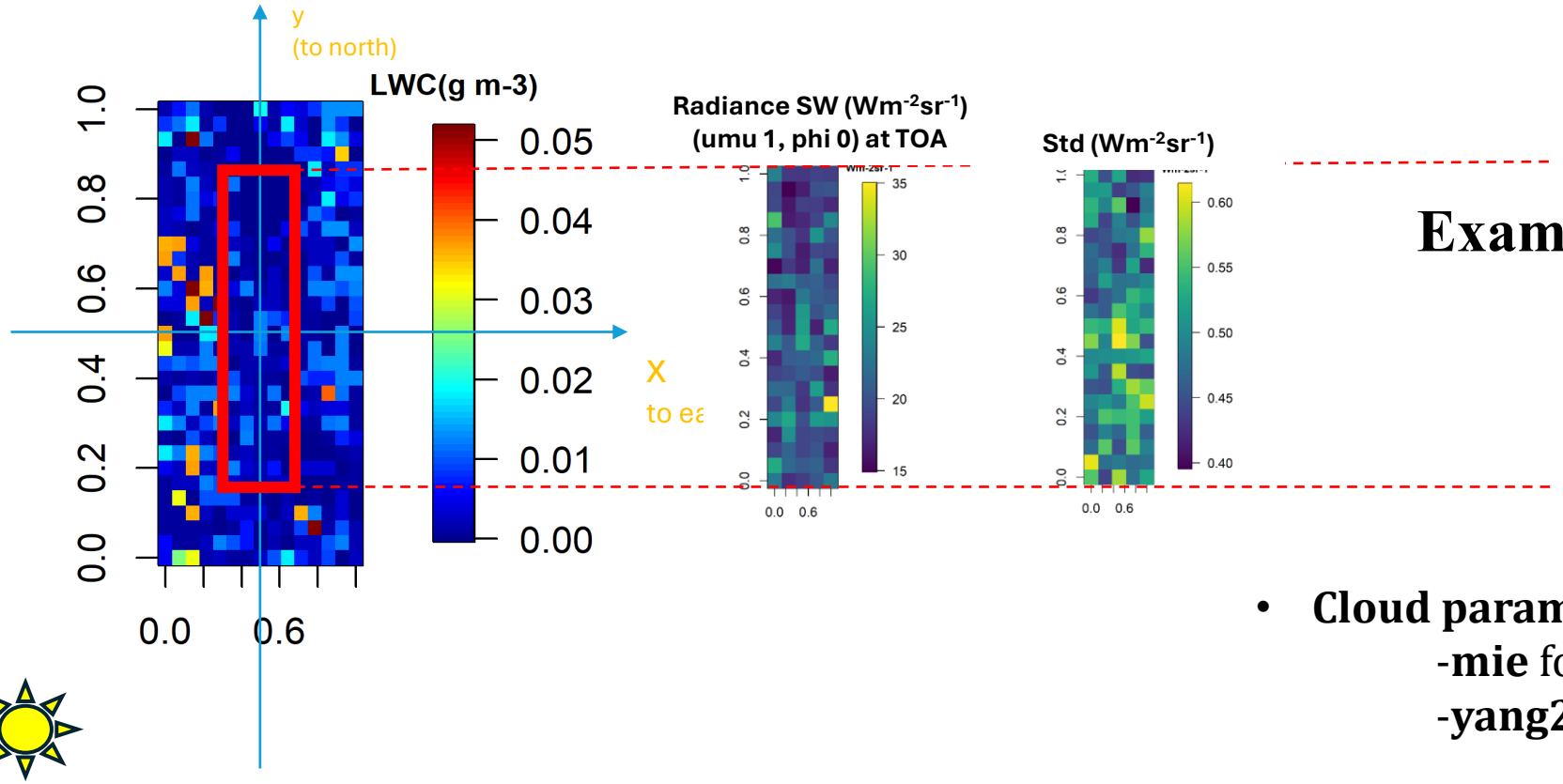
- The question apart from cloudless conditions also, for cloudy conditions (strong 3D effects)

Methods

- **1D** simulations: using analytical model
  solver: **disort** *(Stamnes et al.1988; Buras et al., 2011)*, number of streams: 6
- **3D** simulations: Monte Carlo method
  solver: **MYSTIC** *(Mayer, 2009; Emde and Mayer, 2007; Emde et al., 2016)*,
  forward tracing mode, 10^7 photons

libRadtran

(Mayer and Kylling 2005; Emde et al., 2016)

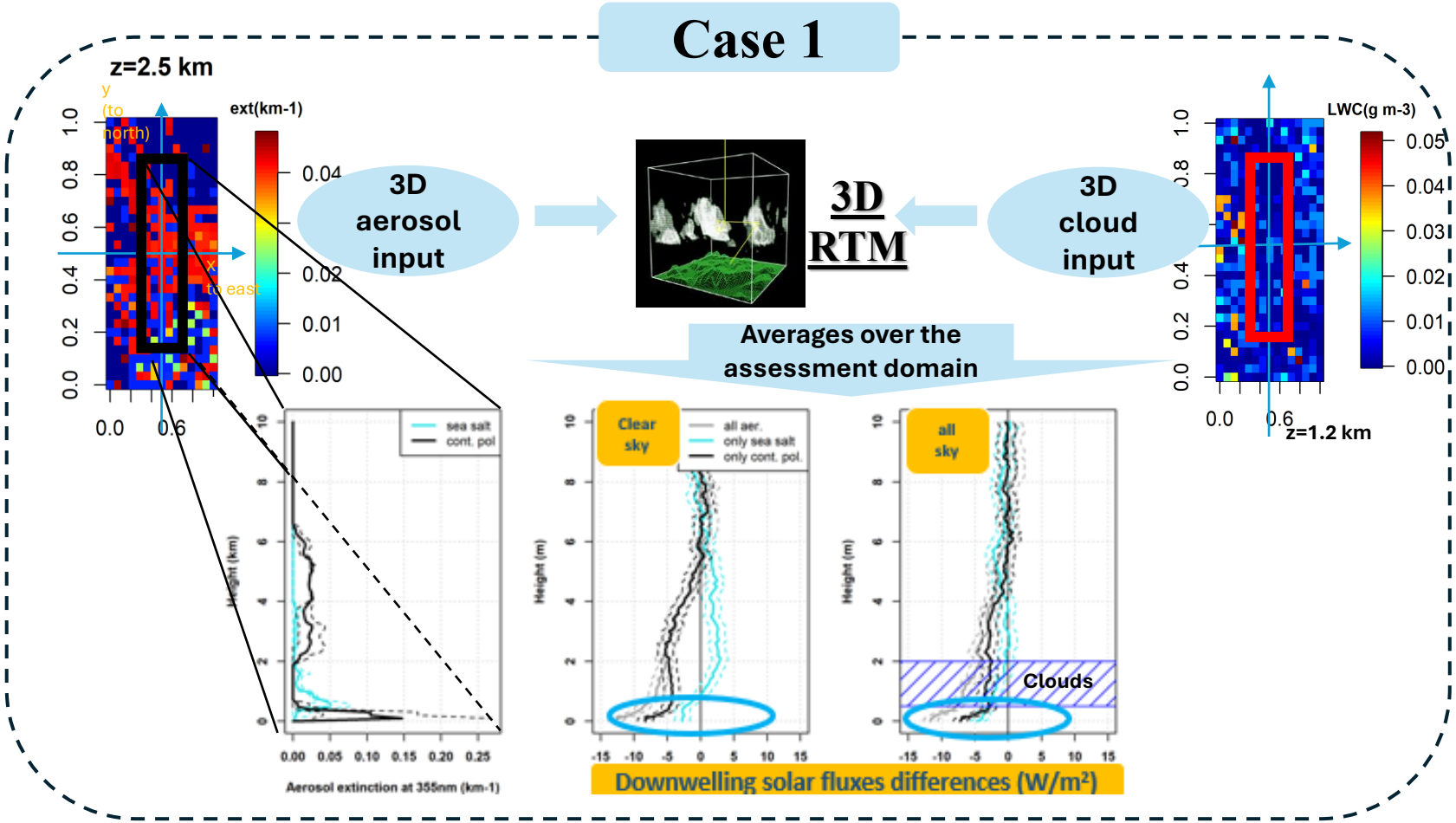


Example 3D run for Only Clouds

- **Cloud parameterizations**:
  -**mie** for water clouds
  -**yang2013** for ice clouds *(Yang et al., 2013)*

Aerosol direct radiative effects (DREs) under realistic 3D cloudy scenes using EarthCARE data

- Do the Aerosol DREs differ between 1D and 3D radiative transfer estimates?
- Which is the effect on Aerosol DREs of the relative position of clouds?



Papachristopoulou et al., in preparation

Participants:

PMOD WRC, CH: **Stelios Kazadzis**, N. Kouremeti, K. Papachristopoulou, A. Moustaka, A. Karanikolas

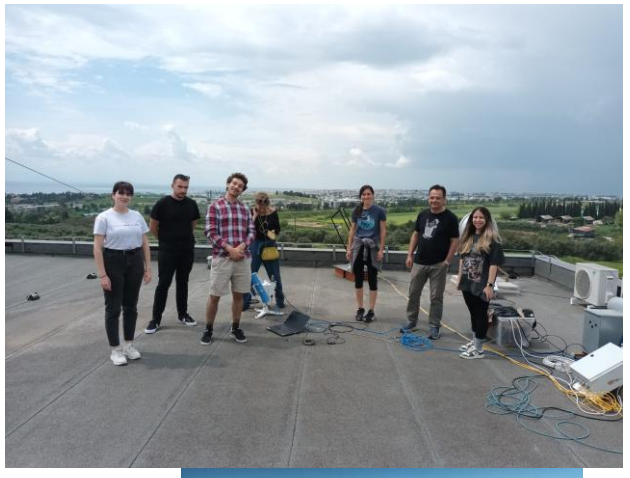
Un. Of Zurich, CH: **Andreas Hüni, Marvin, Wagner**

Aristotle Un. Of Thessaloniki, GR: **Dimitris Balis**, A. Bais, C. Mpiskas, M. Koukouli, K. Garane, K. Michailidis, Master students

Un. Of Patras, GR: **Andreas Kazantzidis**, P. Ioannidis, G. Kosmopoulos

National Obs. Of Athens, GR: **Vasilis Amiridis**, **D. Kouklaki**, E. Marinou

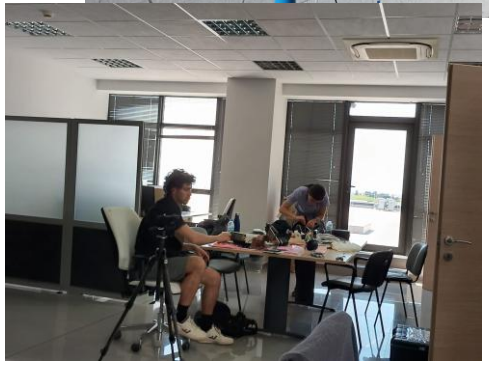
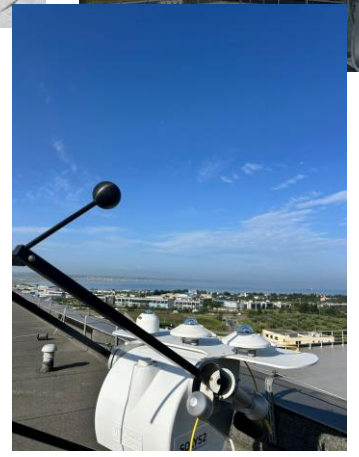
Eratosthenos Center of Excellence, CY: **Rodanthi Mamouri**, **G. Charalampous**, M. Poutli, A. Savva









Radiation closure experiments for the validation of EarthCARE,

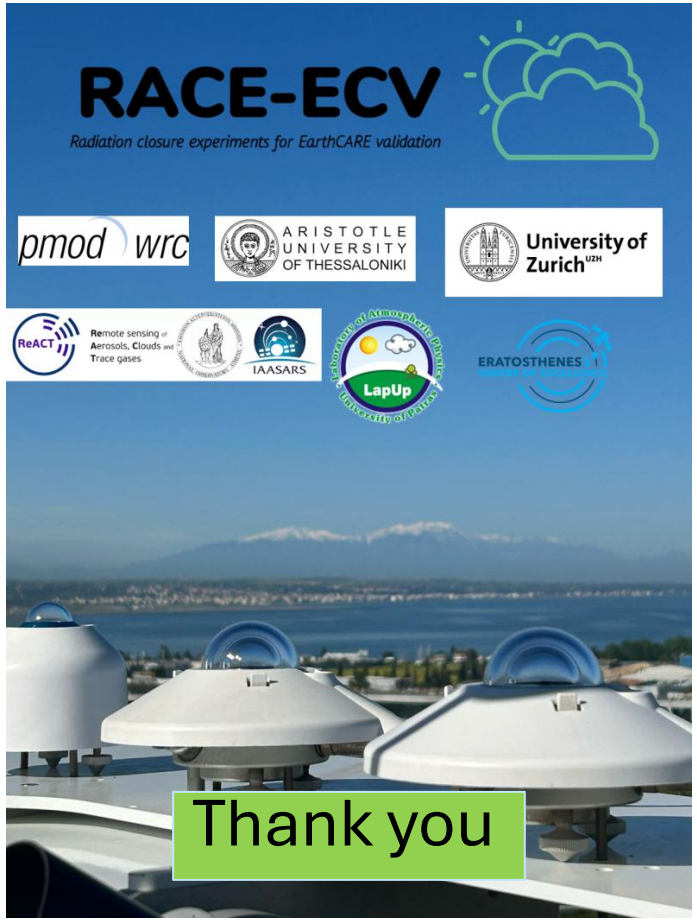
Stelios Kazadzis + collaborators

2026: 2nd campaign

ATARRI

Thank you

HARMONIA
International network for harmonization of atmospheric aerosol retrievals from ground based photometers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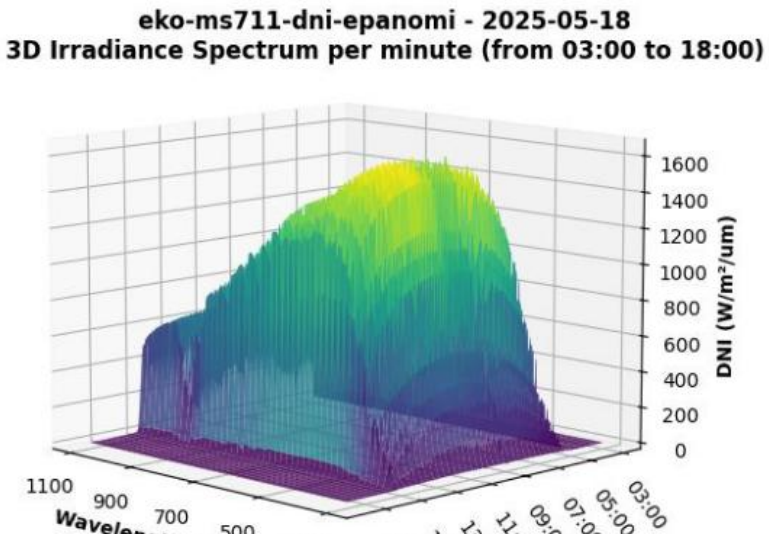
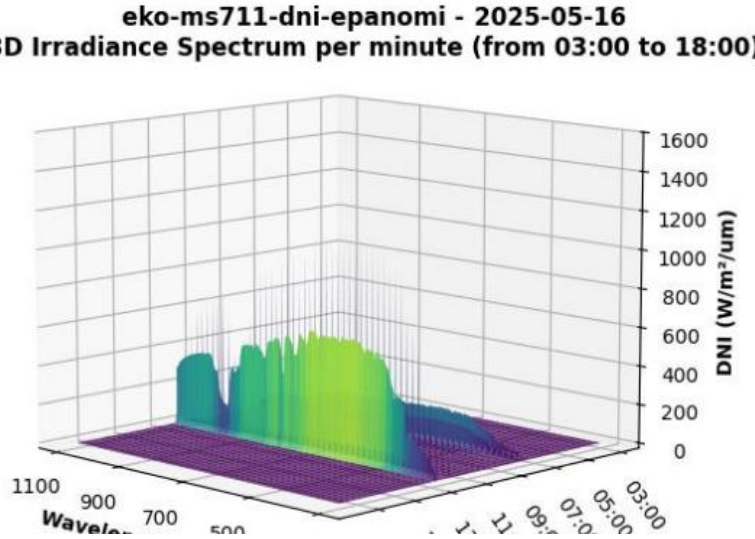
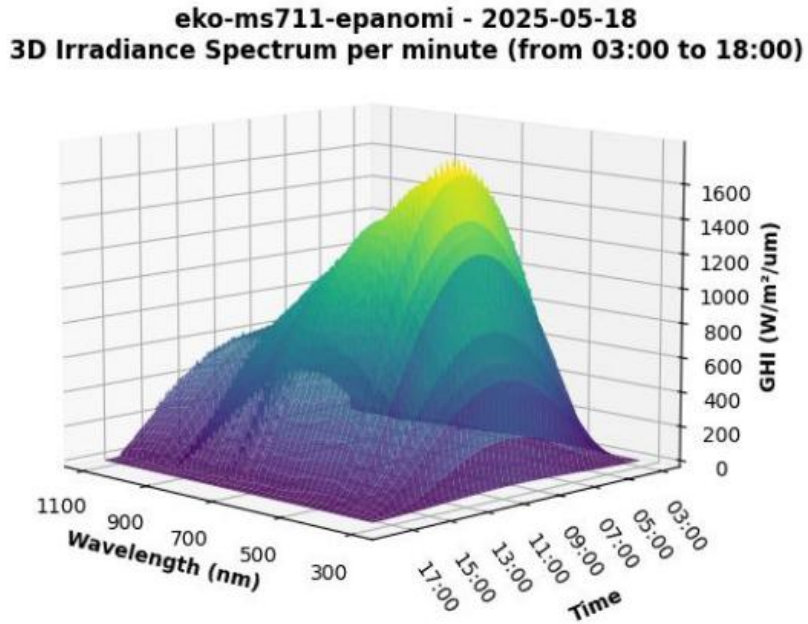
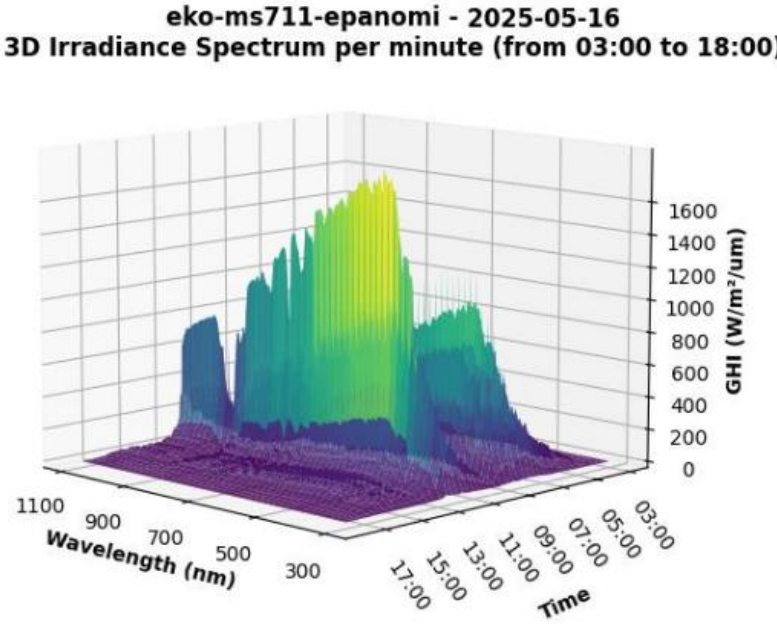
ERATOSTHENES
Thank you

Aerosol direct radiative effects (DREs) under realistic 3D cloudy scenes using EarthCARE data

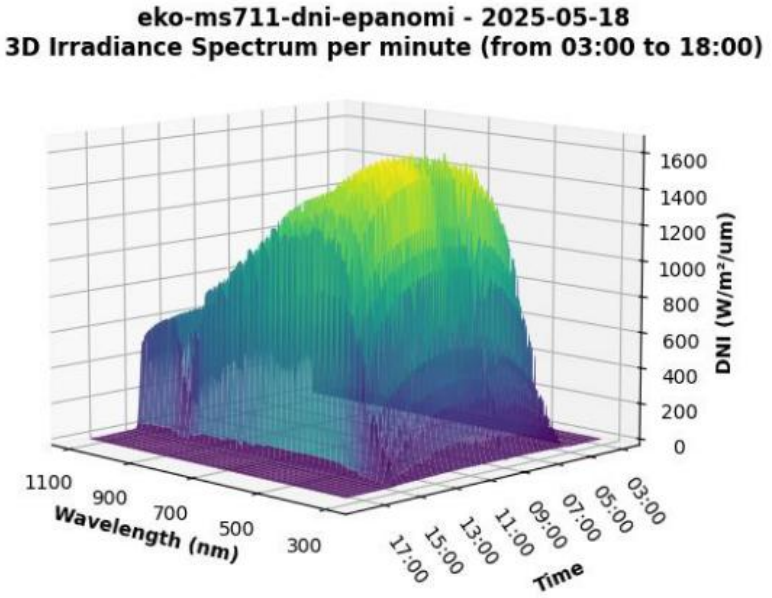


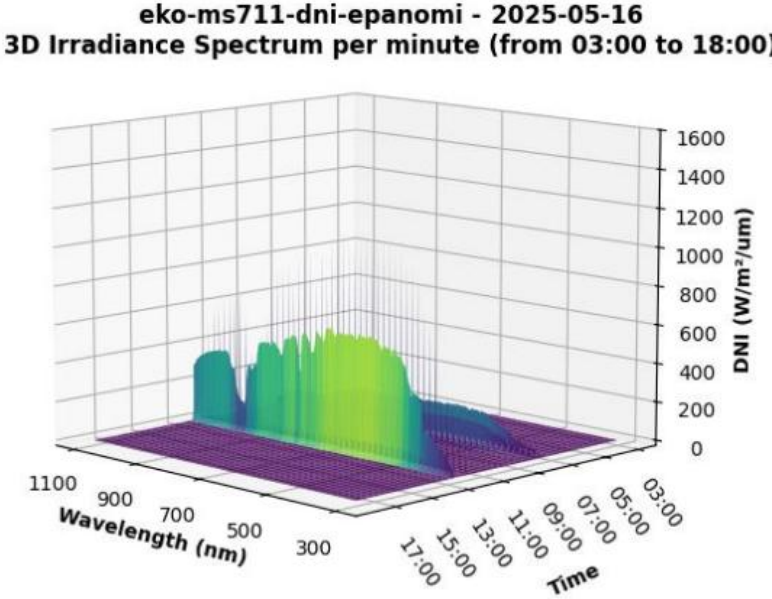


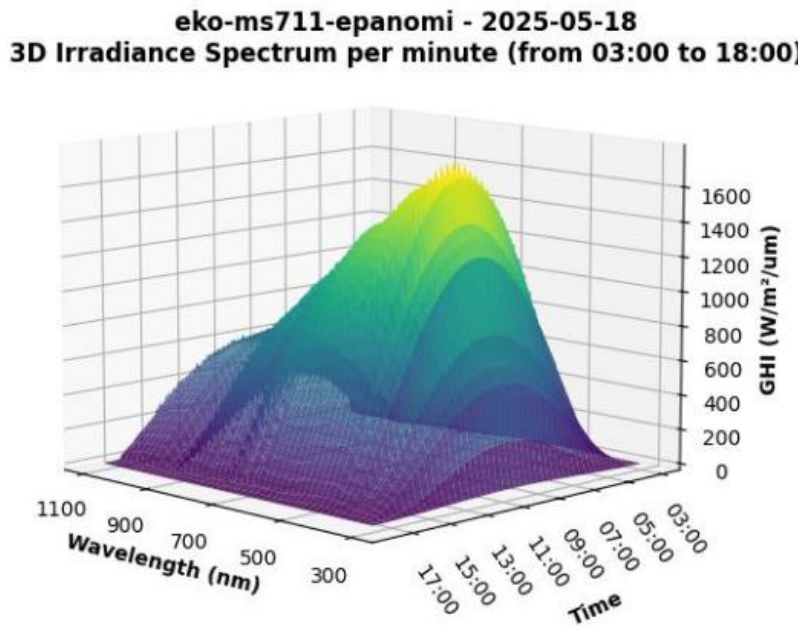


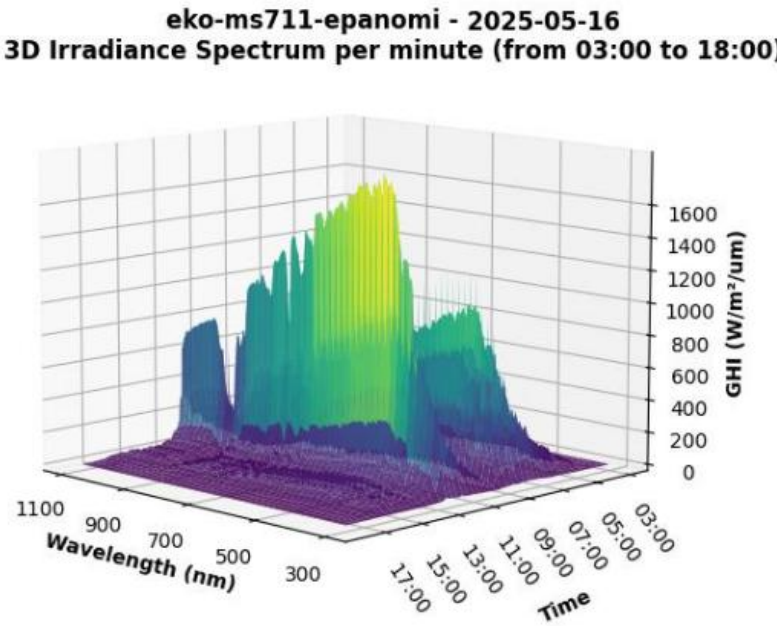


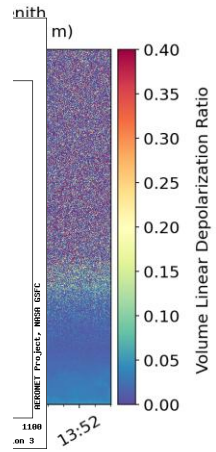
l., in preparation

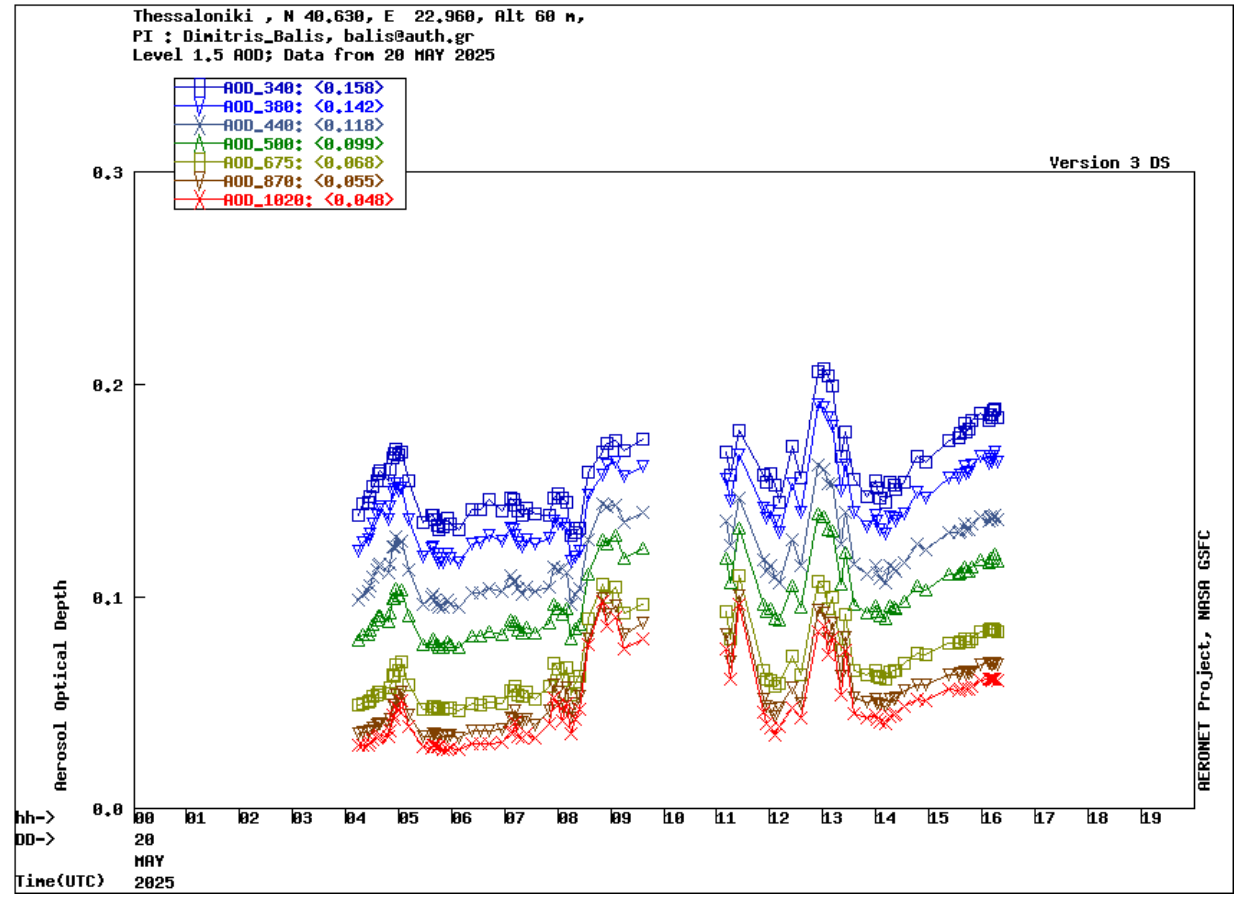

eko-ms711-dni-epanomi - 2025-05-18
3D Irradiance Spectrum per minute (from 03:00 to 18:00)
DNI (W/m²/um)
Wavelength (nm)
Time


eko-ms711-dni-epanomi - 2025-05-16
3D Irradiance Spectrum per minute (from 03:00 to 18:00)
DNI (W/m²/um)
Wavelength (nm)
Time


eko-ms711-epanomi - 2025-05-18
3D Irradiance Spectrum per minute (from 03:00 to 18:00)
GHI (W/m²/um)
Wavelength (nm)
Time

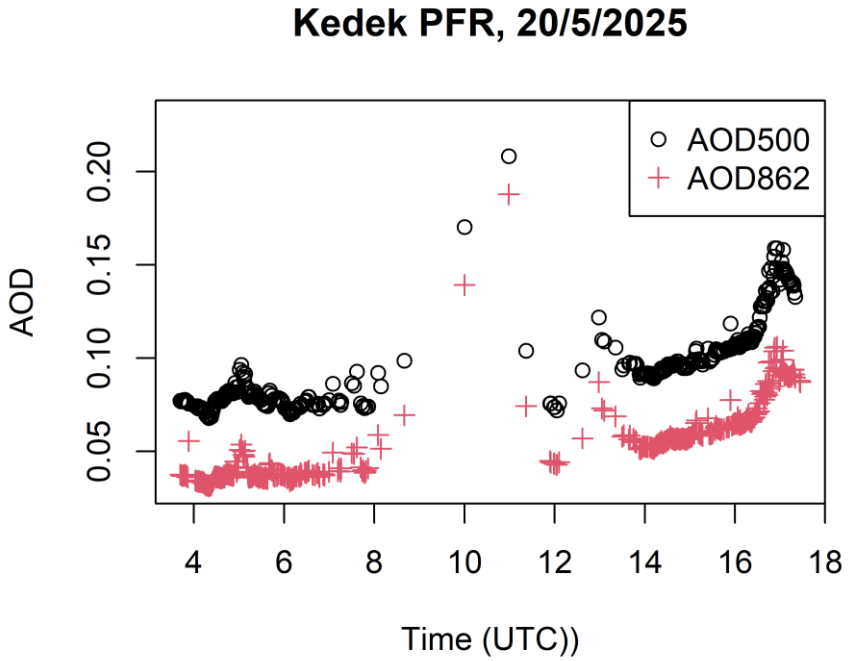

eko-ms711-epanomi - 2025-05-16
3D Irradiance Spectrum per minute (from 03:00 to 18:00)
GHI (W/m²/um)
Wavelength (nm)
Time


Volume Linear Depolarization Ratio
13:52


Thessaloniki , N 40.630, E 22.960, Alt 60 m,
PI : Dimitris_Balis, balis@auth.gr
Level 1.5 AOD; Data from 20 MAY 2025
AOD_340: <0.158>
AOD_380: <0.142>
AOD_440: <0.118>
AOD_500: <0.099>
AOD_675: <0.068>
AOD_870: <0.055>
AOD_1020: <0.048>
Version 3 DS
Aerosol Optical Depth
0.3
0.2
0.1
0.0
hh->
DD->
Time(UTC)
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19
20
MAY
2025
AERONET Project, NASA GSFC

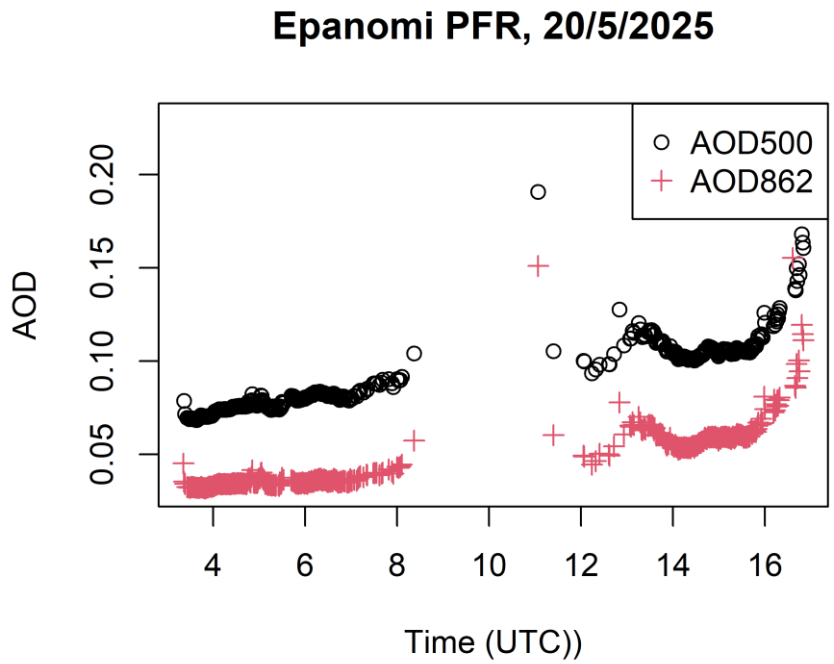
Kedek		
MSI AOT 670nm	**PFR AOD 500nm**	**PFR AOD 675nm**
Mean (11x11, N=2) 0.25 (sd 0.001) +/-0.31!! (quality status 0)	0.11 overpass (flag8)	0.09 overpass (flag8)

Kedek	
MSI AOT 865nm	**PFR AOD 862nm**
Mean (51x51, N=8) 0.105 (sd 0.009) +/-0.004!! (quality status 0)	0.072 overpass (flag8)



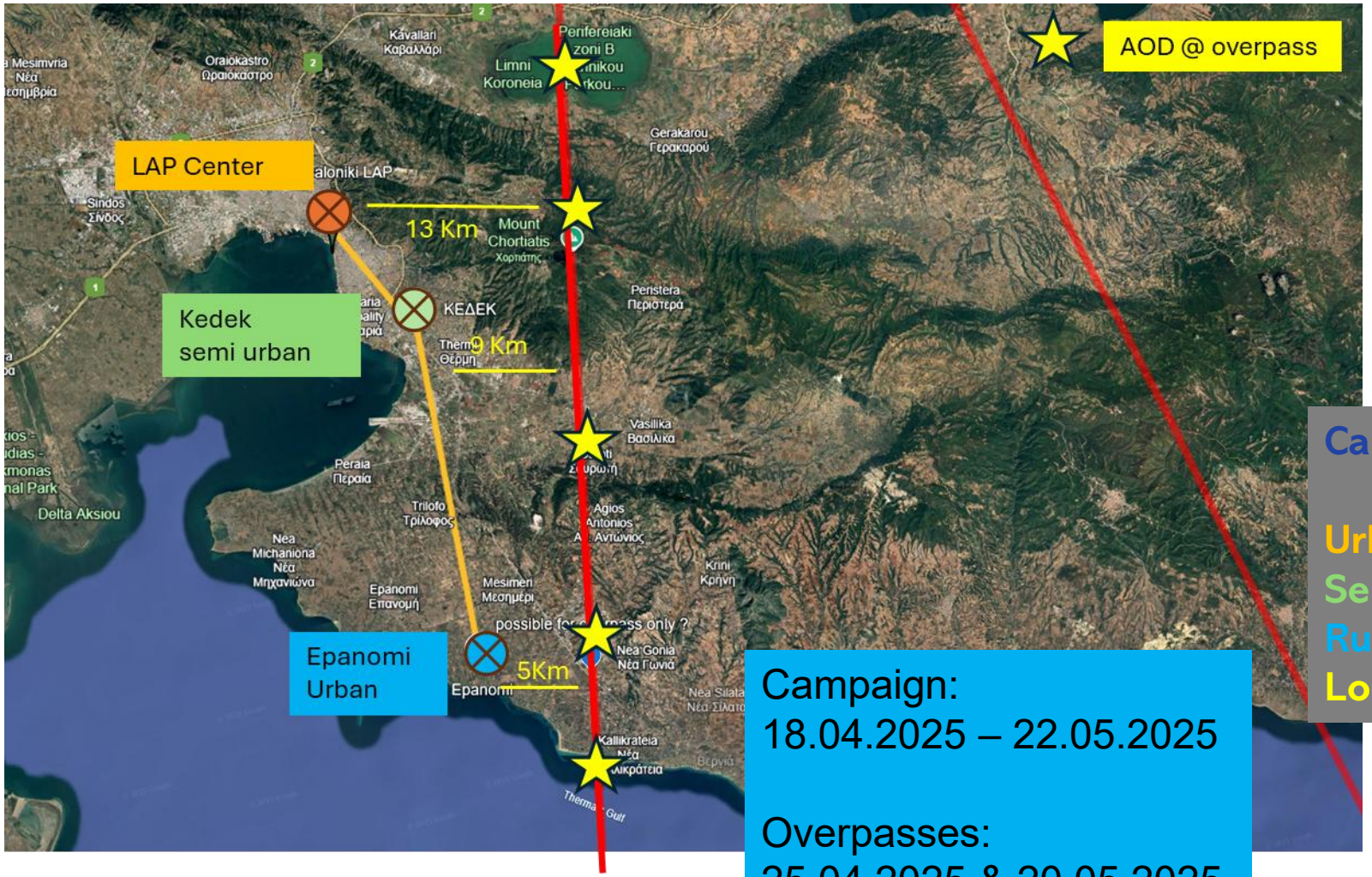
Epanomi		
MSI AOT 670nm	**PFR AOD 500nm**	**PFR AOD 675nm**
Mean (21x21, N=358) 0.26 (sd 0.02) +/-0.32!! (quality status 0)	0.12 overpass (flag8)	0.08 overpass (flag8)

Epanomi	
MSI AOT 865nm	**PFR AOD 862nm**
Mean (21x21, N=113) 0.130 (sd 0.015) +/-0.003 (quality status 0)	0.07 overpass (flag8)



Radiation closure experiments for the validation of EarthCARE

RACE-ECV
Radiation closure experiments for EarthCARE validation



Campaign design

Urban location
Semi urban
Rural
Locations at overpass

Campaign:
18.04.2025 – 22.05.2025

Overpasses:
25.04.2025 & 20.05.2025