Direct Radiative Effects of Dust Events Over Limassol, Cyprus in 2024 using Ground-Based Measurements and Modelling

Georgia Charalampous [1,2*], Konstantinos Fragkos [3], Ilias Fountoulakis [4], Kyriakoula Papachristopoulou[5], Argyro Nisantzi[1,2], Rodanthi-Elisavet Mamouri[1,2], Diofantos Hadjimitsis[2,1] and Stelios Kazadzis[5]

Department of Resilience Society/ Department of Environment and Climate, Eratosthenes Centre of Excellence, Limassol, Cyprus

Department of Civil Engineering & Geomatics, Cyprus University of Technology, Limassol, Cyprus

The Cyprus Institute, Konstantinou Kavafi 20, 2121 Aglantzia, Nicosia, Cyprus

Research Centre for Atmospheric Physics and Climatology, Academy of Athens, Athens, Greece

Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center, Davos, Switzerland

*Presenting author e-mail: georgia.charalambous@eratosthenes.org.cy

CONSORTIUM

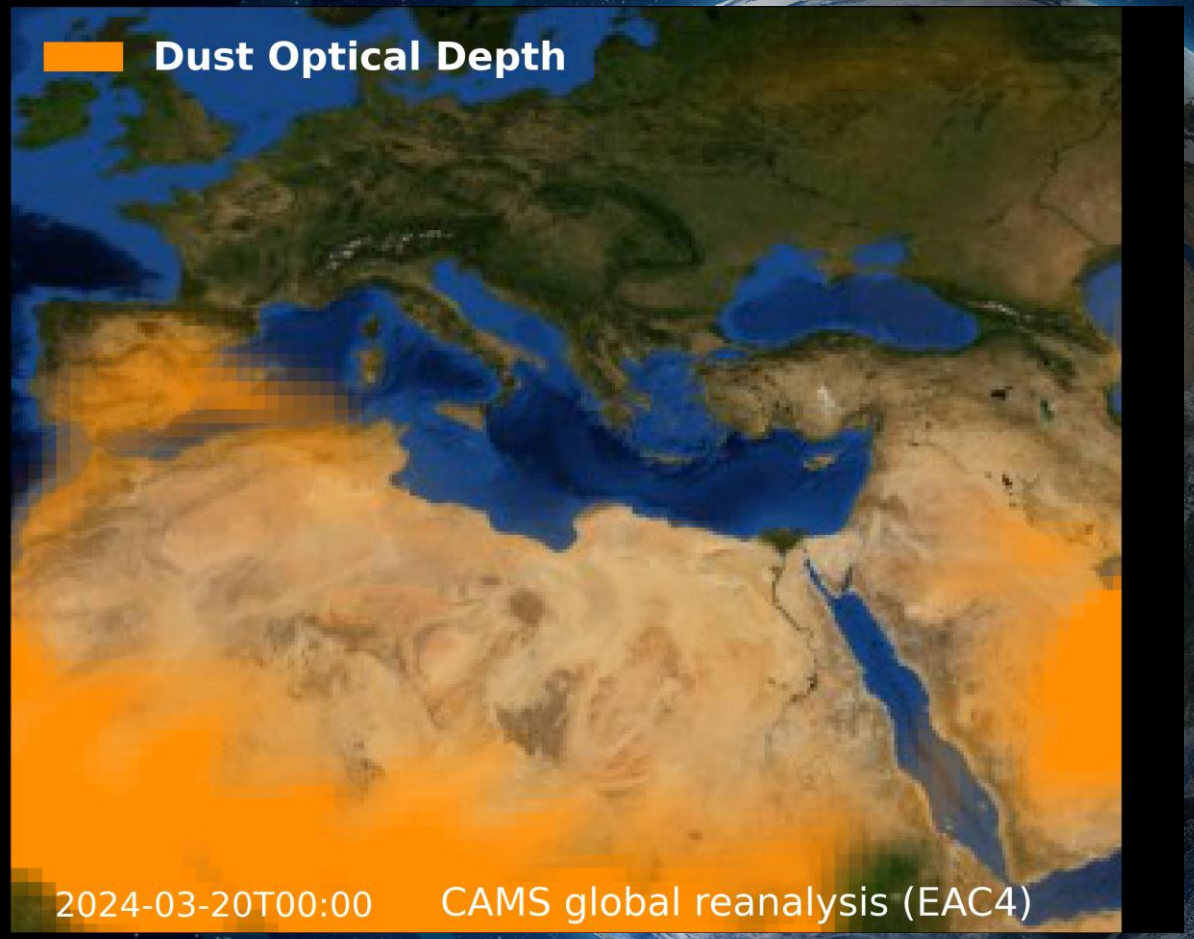
AFFILIATED ENTITIES

This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".

This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".

This project is co-funded by the Cyprus University of Technology.

Introduction



- Aerosols can change surface radiation fluxes by both absorbing and scattering solar radiation
- Dust aerosols are known to efficiently absorb solar radiation, especially at lower wavelengths.

Dust aerosols, particularly from the Sahara and Arabian Peninsula, play a significant role in regional and global climate by affecting solar radiation

Study Aim

Quantify direct radiative effects of major dust events in 2024.

Combine:Radiative transfer modeling (LibRadtran)Ground-based measurements and satellite observations

Methodology

Methodology Workflow

Dust Day Identification
Cloud-free detection
(All-sky camera, AERONET filtering)

Aerosol Classification
AOD & Ångström exponent
+ Dust typing scheme

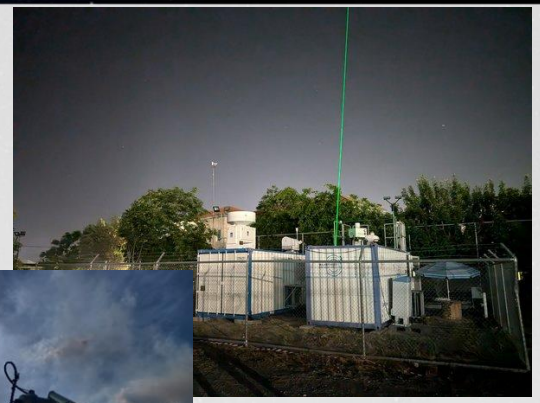
Verification
PollyXT lidar profiles
+ MODIS imagery

Source Attribution
HYSPLIT backward trajectories

Radiative Simulations
libRadtran (AOD, SSA, ASY,
water vapour, ozone, albedo)

Model Evaluation
Measured vs. modeled GHI

Attenuation Calculation
ΔSW = Measured GHI − Model (aerosol-free)



- Instruments and Model:

1. AERONET Cimel Sun Photometer
2. Pyranometer and Sky Camera
3. PollyXT Lidar
4. MODIS and OMI Satellite Data
5. LibRadtran Radiative Transfer Model

Model Input	Source
RTE	Disort
Solar flux	Kurudz_o.1
Absorption parameterisation	REPTRAN Fine
Surface albedo	AERONET
O_3 total column	OMI
H_2O total column	AERONET
Number of streams	6

CONSORTIUM
Cyprus University of Technology · DLR · TROPOS · DEC · ERATOSTHENES CENTRE OF EXCELLENCE
AFFILIATED ENTITIES
CYRIC · pmod wrc

This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".

This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".

Cyprus University of Technology

This project is co-funded by the Cyprus University of Technology.

The 3 major events

Event1	AOD_500nm		440-870_Angstrom_Exponent	
	mean	std	mean	std
Date				
2024-03-26	0.415	0.054	0.254	0.061
2024-03-27	0.294	0.036	0.231	0.013
2024-03-28	0.448	0.066	0.191	0.021
2024-03-29	0.486	0.030	0.236	0.052
2024-03-30	0.372	0.029	0.350	0.082
2024-03-31	0.280	0.007	0.382	0.018
2024-04-01	0.269	0.014	0.425	0.056
2024-04-02	0.241	0.029	0.498	0.038
2024-04-03	0.172	0.026	0.584	0.148
2024-04-04	0.271	0.115	0.282	0.079

Event2	AOD_500nm		440-870_Angstrom_Exponent	
	mean	std	mean	std
Date				
2024-04-17	0.134	0.032	0.845	0.114
2024-04-18	0.351	0.097	0.246	0.064
2024-04-19	0.214	0.063	0.543	0.132
2024-04-20				
2024-04-21				
2024-04-22	0.611	0.159	0.186	0.024
2024-04-23	0.379	0.017	0.204	0.017
2024-04-24	0.531	0.021	0.207	0.013
2024-04-25				
2024-04-26				
2024-04-27				
2024-04-28	0.277	0.022	0.339	0.024

Event3	AOD_500nm		440-870_Angstrom_Exponent	
	mean	std	mean	std
Date				
2024-05-15	0.142	0.036	1.315	0.110
2024-05-16	0.150	0.024	1.172	0.173
2024-05-17	0.400	0.051	0.311	0.041
2024-05-18	0.372	0.049	0.248	0.047
2024-05-19	0.464	0.049	0.289	0.048
2024-05-20	0.413	0.022	0.314	0.069
2024-05-21	0.399	0.016	0.400	0.057
2024-05-22				
2024-05-23	0.276	0.103	0.273	0.068
2024-05-24	0.166	0.015	0.776	0.075
2024-05-25	0.205	0.044	0.927	0.127

CONSORTIUM
Cyprus University of Technology, DLR, TROPOS, DEC, ERATOSTHENES CENTRE OF EXCELLENCE
AFFILIATED ENTITIES
CYRIC, pmod wrc

This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".

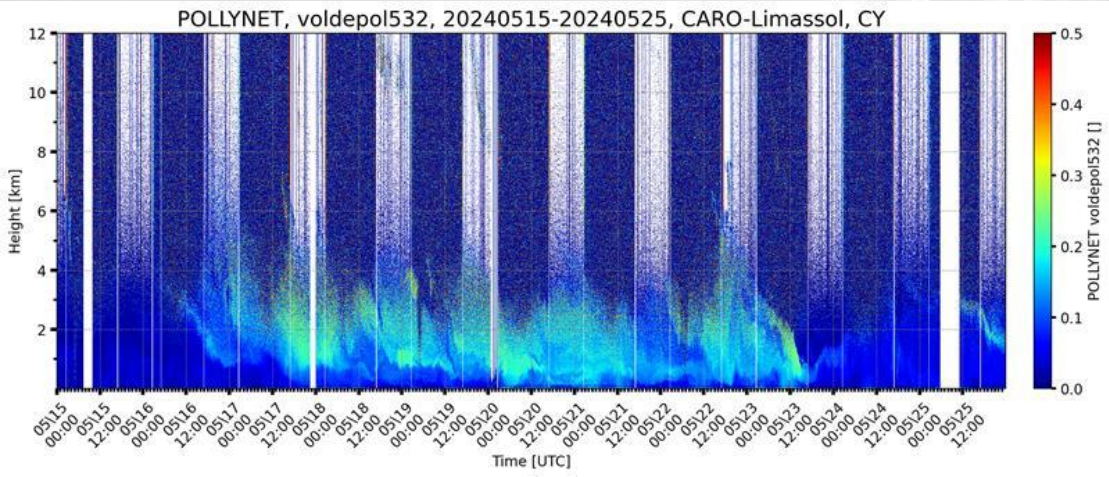
This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".

Cyprus University of Technology

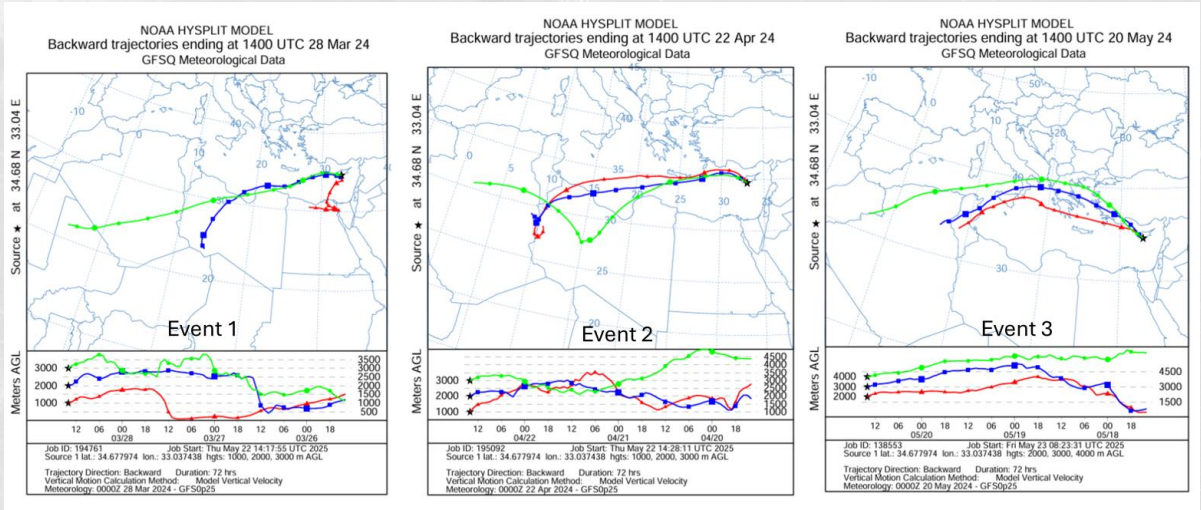
This project is co-funded by the Cyprus University of Technology.

Modis Images from the three events over Cyprus (GIBS/Worldview).

CONSORTIUM
Cyprus University of Technology
DLR
TROPOS
DEC
ERATOSTHENES CENTRE OF EXCELLENCE
AFFILIATED ENTITIES
CYRIC
pmod wrc
This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".
This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".
Cyprus University of Technology
This project is co-funded by the Cyprus University of Technology.



PollyXT lidar volume linear depolarization ratio at 532 nm over Limassol, Cyprus, from 15 to 25 May 2024 (event 3).



Origins traced to Sahara Desert

CONSORTIUM
AFFILIATED ENTITIES

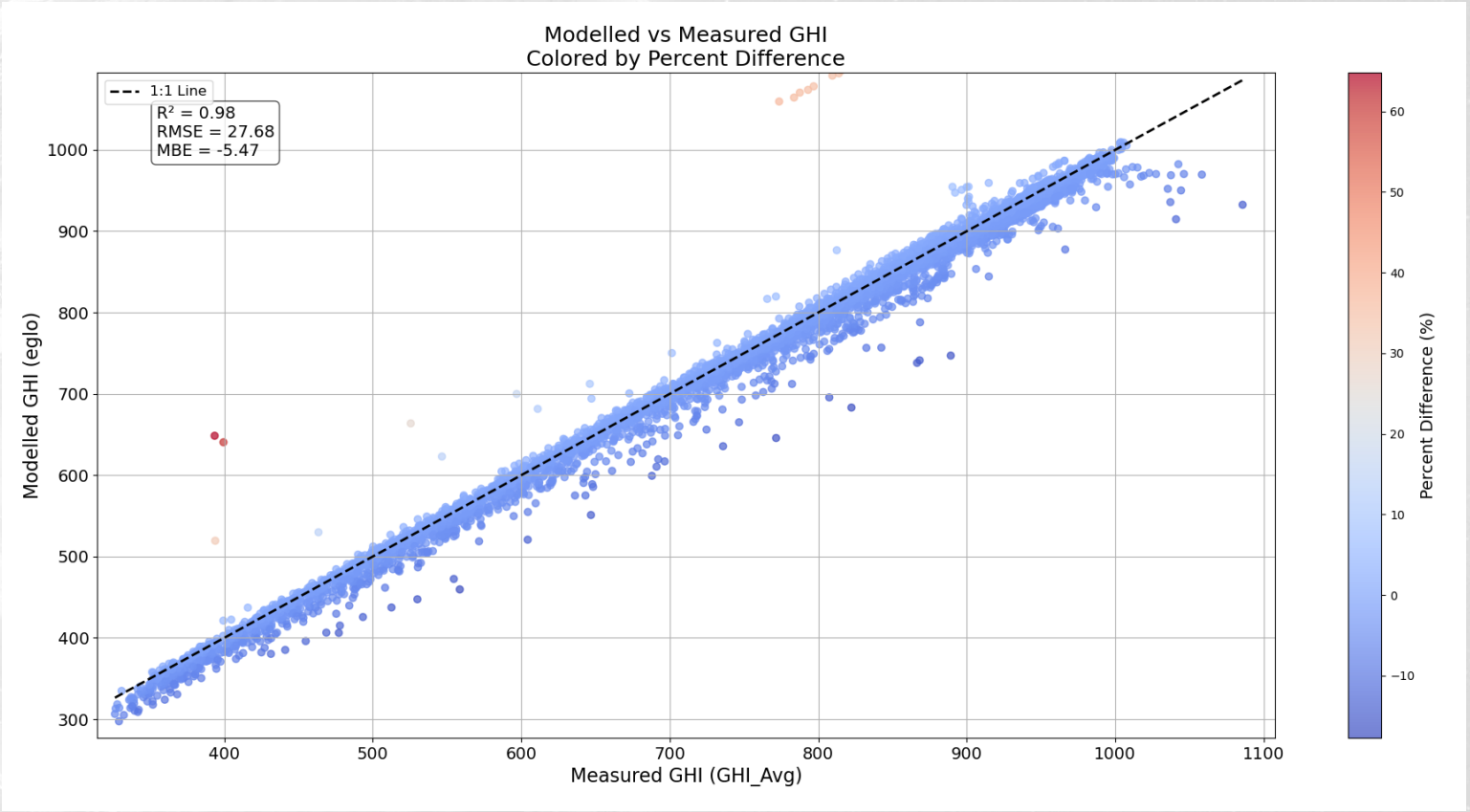
This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".

This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".

This project is co-funded by the Cyprus University of Technology.

Radiative Transfer Model

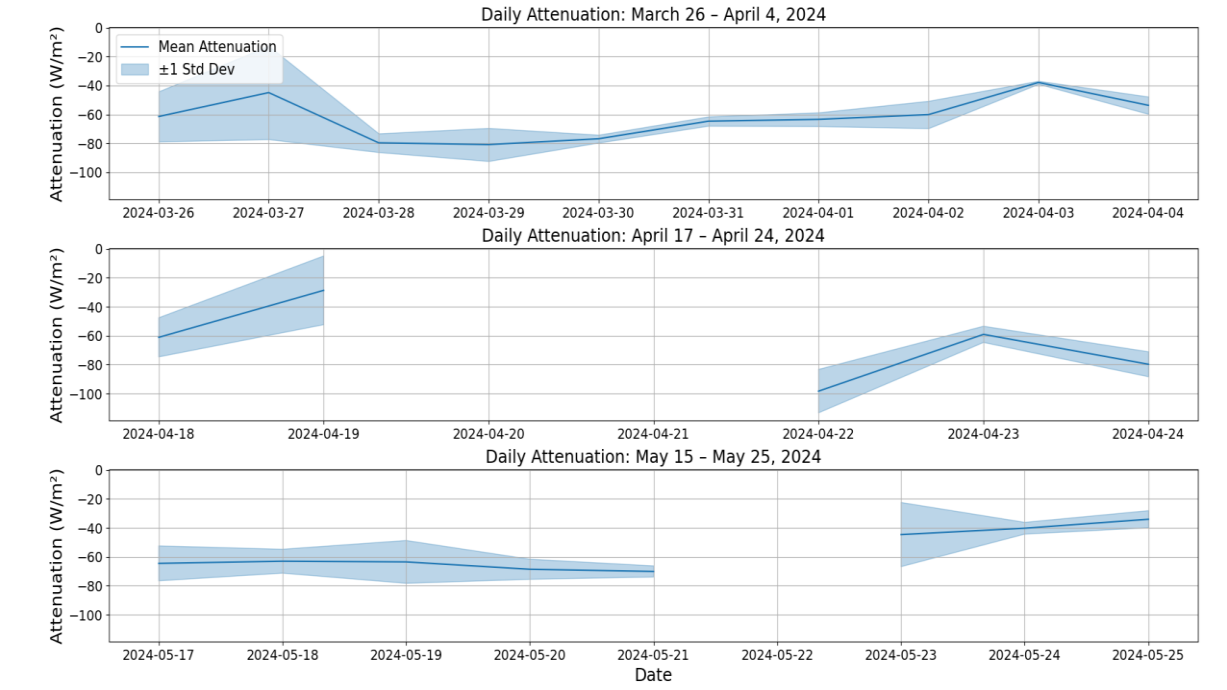
Model Input	Source
RTE	Disort
Solar flux	Kurudz_o.1
Absorption parameterisation	REPTRAN Fine
Surface albedo	AERONET
O_3 total column	OMI
H_2O total column	AERONET
Number of streams	6

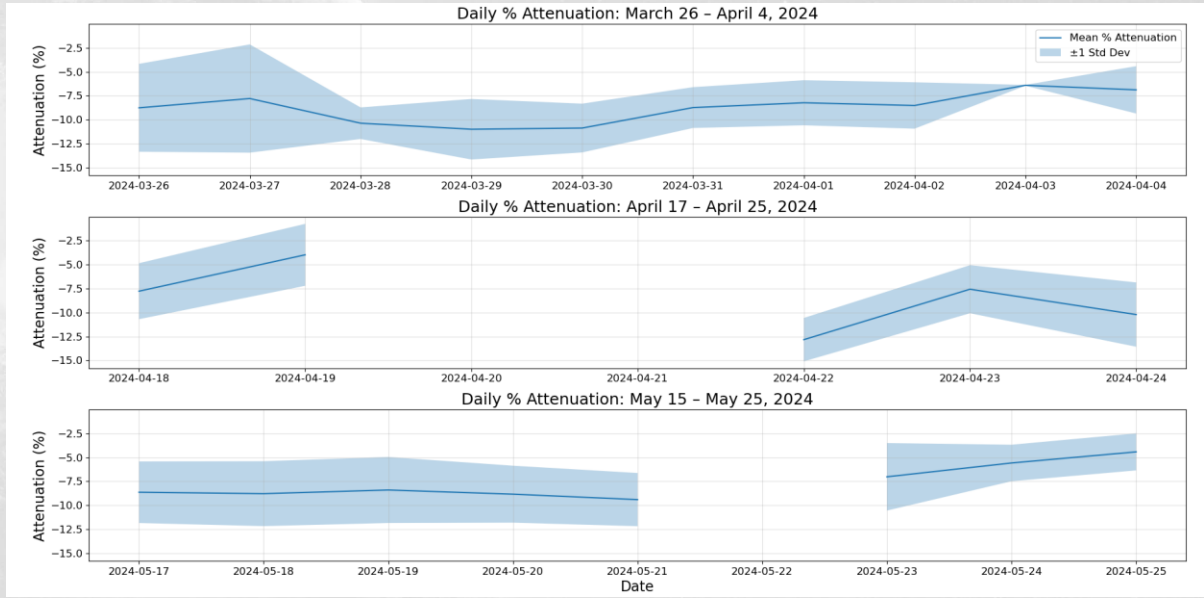


83.97% of values within ±3%
93.12% of values within ±5%
98.56% of values within ±10%

- Comparison of measured vs. modeled irradiance.
- R^2 = **0.98**, RMSE ≈ **27.7 W/m²**.

CONSORTIUM
AFFILIATED ENTITIES
This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".
This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".
This project is co-funded by the Cyprus University of Technology.





- Daily shortwave attenuation exceeded –100 W/m².
- Strong correlation with high AOD

Each event showed significant reductions in surface solar irradiance, with peaks exceeding −10%

CONSORTIUM
Cyprus University of Technology · DLR · TROPOS Leibniz Institute for Tropospheric Research · DEC Communications · Eratosthenes Centre of Excellence
AFFILIATED ENTITIES
CYRIC · pmod wrc
This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".
This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".
Cyprus University of Technology
This project is co-funded by the Cyprus University of Technology.

Key Findings:

•Three major dust events were identified in 2024 (March 28, April 22, May 19) over Limassol, Cyprus.

•Dust layers, confirmed by lidar profiles, MODIS imagery, and HYSPLIT trajectories.

•Strong attenuation of solar radiation observed: daily reductions exceeded −100 W/m².

•Radiative transfer simulations (LibRadtran) driven by AERONET inputs showed excellent agreement with pyranometer data ($R^2 \approx 0.98$).

Conclusions

- Mineral dust significantly reduces surface solar irradiance during transport events in Limassol, Cyprus.
- Accurate aerosol optical properties (AOD, SSA, asymmetry parameter) and vertical profiling are crucial for robust radiative assessments.
- The combined ground-based–satellite–modeling approach is effective for quantifying dust radiative effects.
- Findings are directly relevant for solar energy forecasting and regional climate studies in the Eastern Mediterranean.

CONSORTIUM
AFFILIATED ENTITIES
This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".
This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".
This project is co-funded by the Cyprus University of Technology.

Thank you for your attention

CONSORTIUM
AFFILIATED ENTITIES
This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No 857510".
This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and and Development".
This project is co-funded by the Cyprus University of Technology.