



ITALIAN NATIONAL AGENCY FOR
NEW TECHNOLOGIES, ENERGY AND
SUSTAINABLE ECONOMIC DEVELOPMENT



Aerosol and radiation measurements at the Lampedusa Climate Observatory: from satellite validation to solar energy production

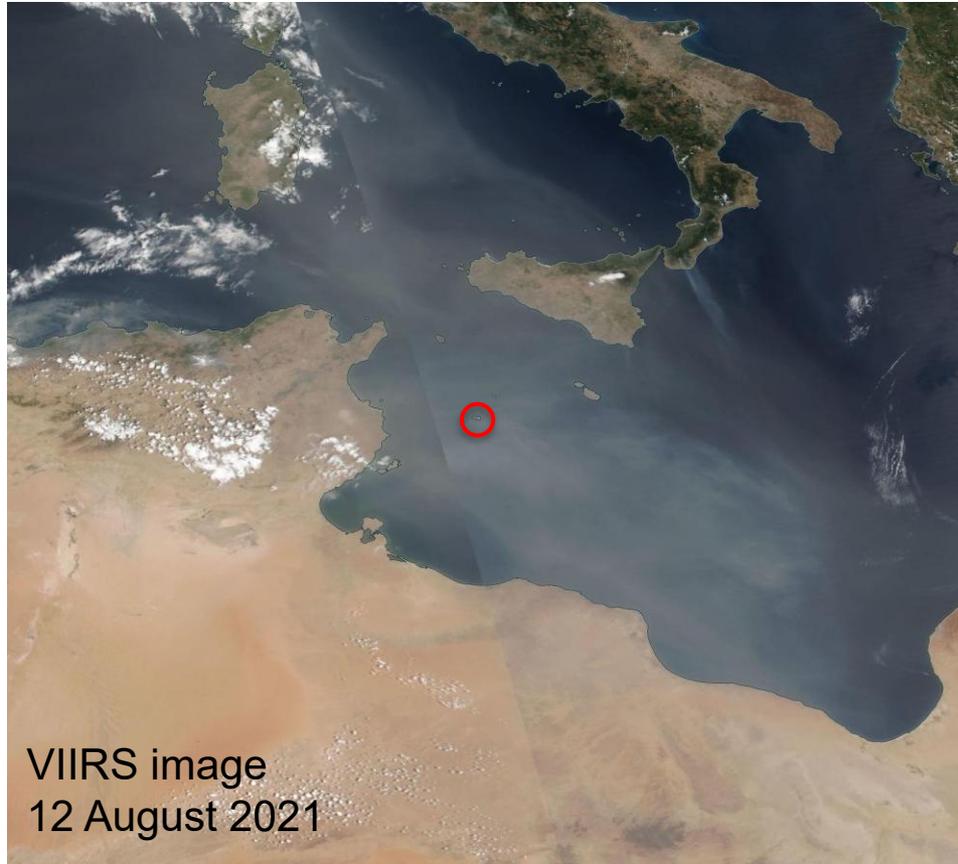
HARMONIA WG3 meeting

Limassol, Cyprus, 16-17 June 2025

Daniela Meloni, ENEA, Laboratory for Models and Measurements for Air Quality, and Climate Observations

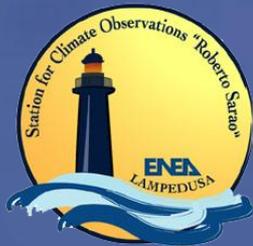


Where is Lampedusa?



VIIRS image
12 August 2021

Lampedusa: an Integrated Observatory



Terrestrial Ecosystem
Observatory (2023)
35.53 °N, 12.54° E

Atmospheric
Observatory (1997)
35.52 °N, 12.63° E

Oceanographic
Observatory (2015)
35.49 °N, 12.47° E



www.lampedusa.enea.it

Google Earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

6 km



The Atmospheric Observatory

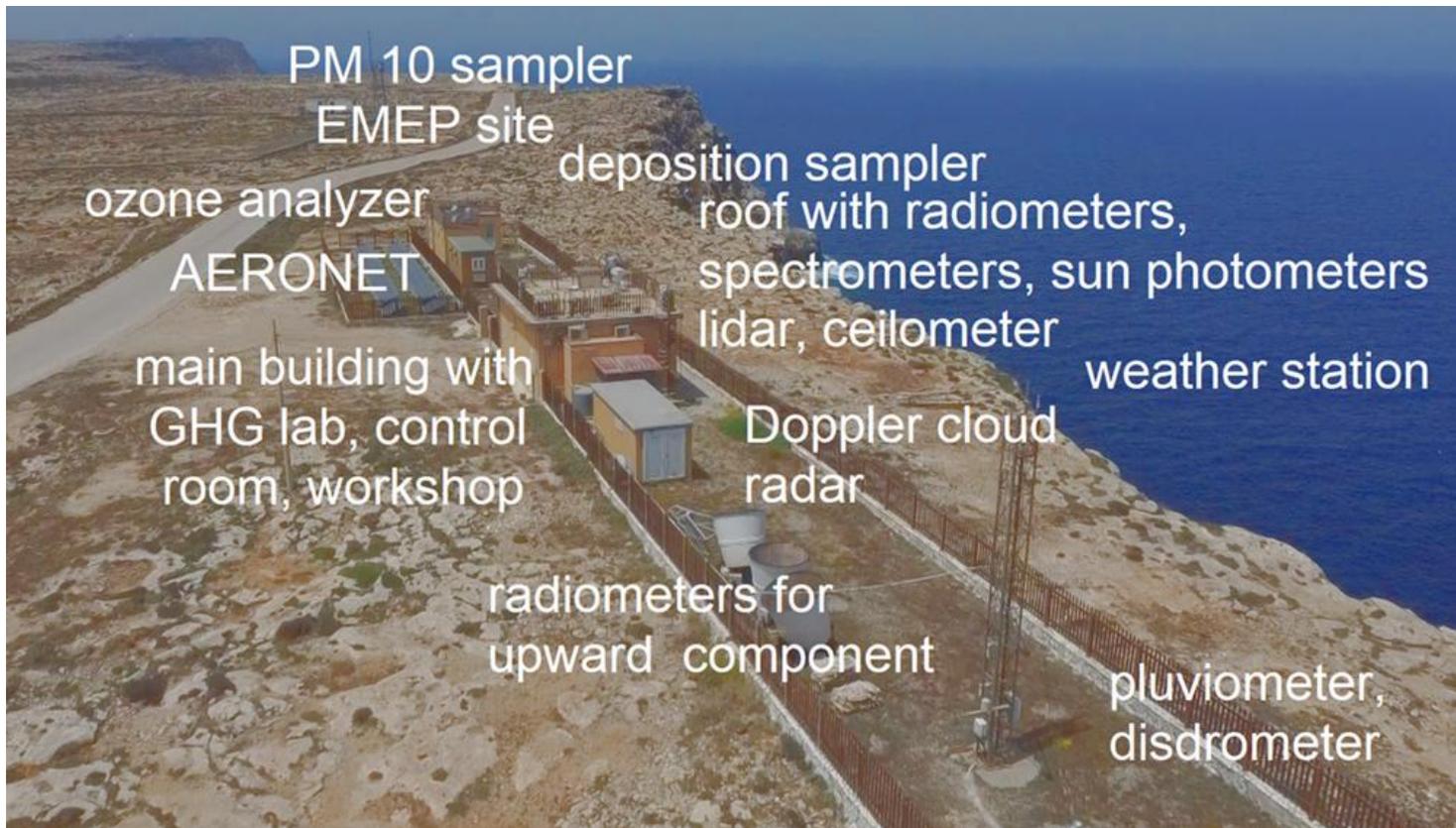


The Atmospheric Observatory

Under labeling



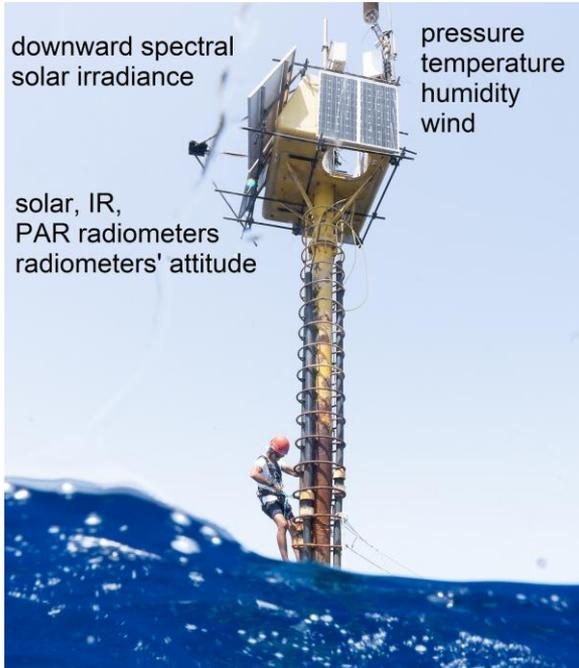
ICOS | Integrated Carbon Observation System



The Atmospheric Observatory

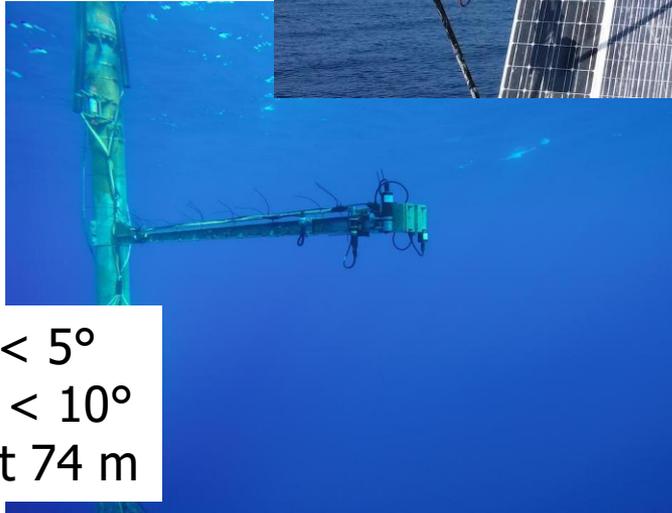


The Oceanographic Observatory

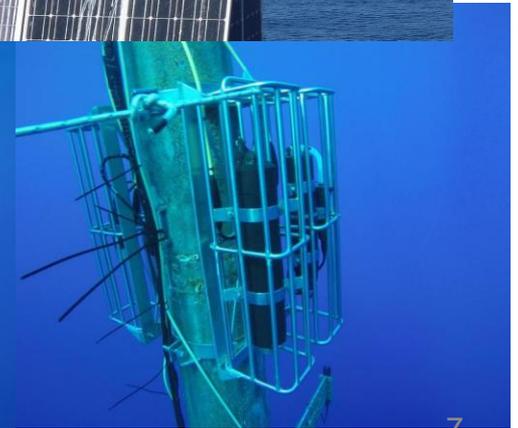


emso
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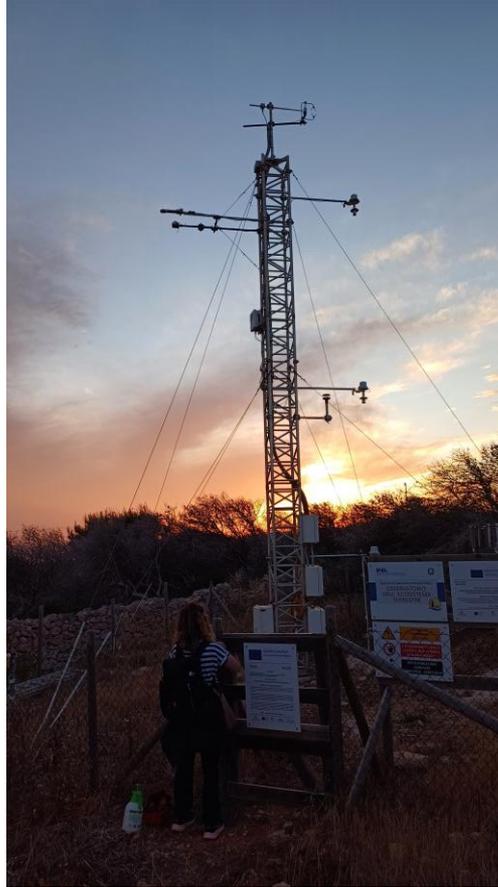
ICOS | Integrated
Carbon
Observation
System



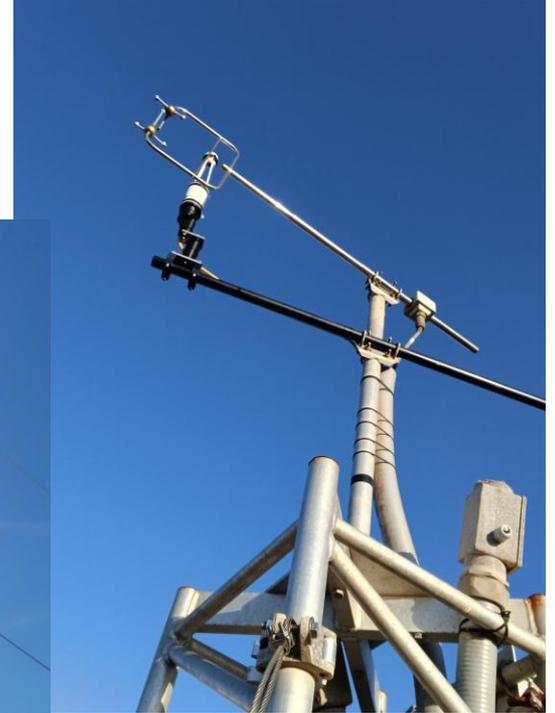
Rotation $< 5^\circ$
Pitch/roll $< 10^\circ$
Bottom at 74 m



The Terrestrial Ecosystem Observatory

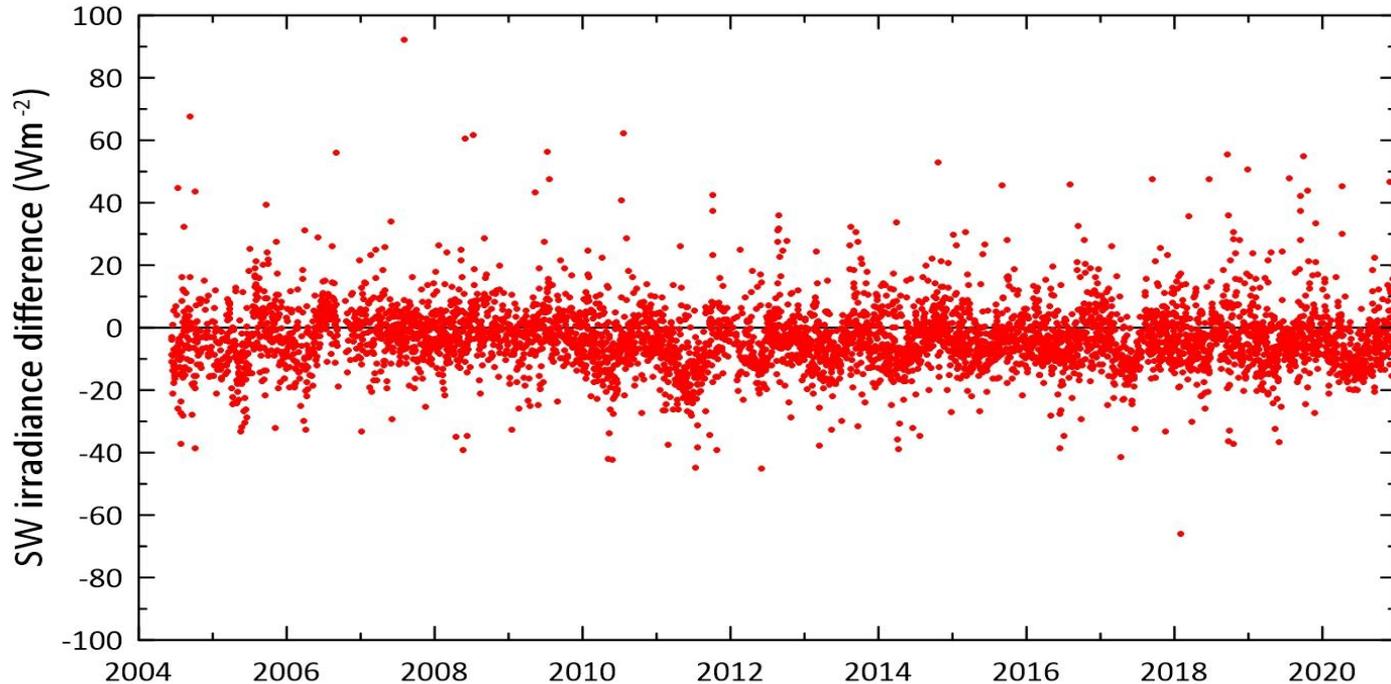


ICOS |  Integrated
Carbon
Observation
System

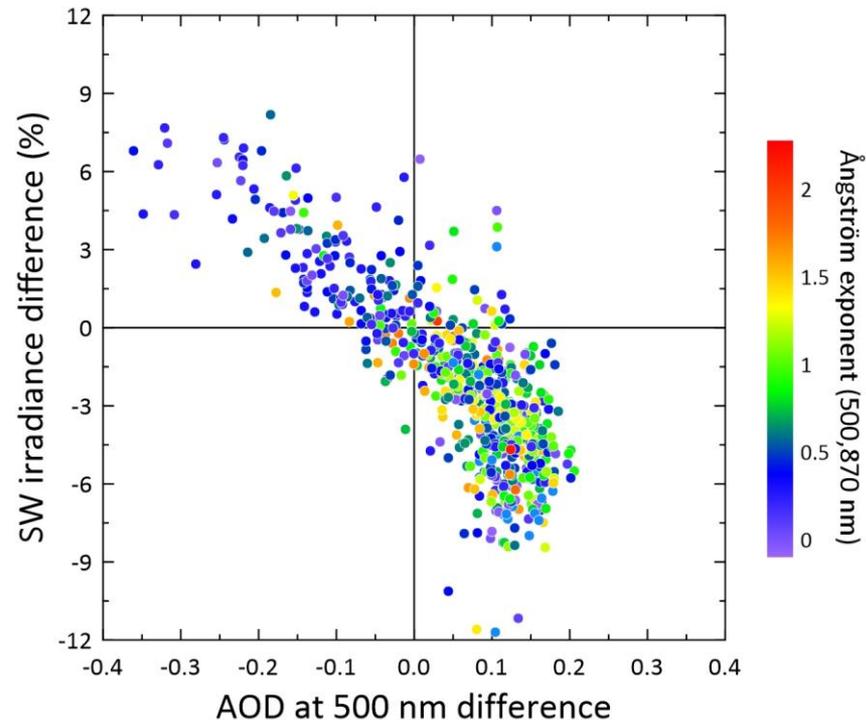
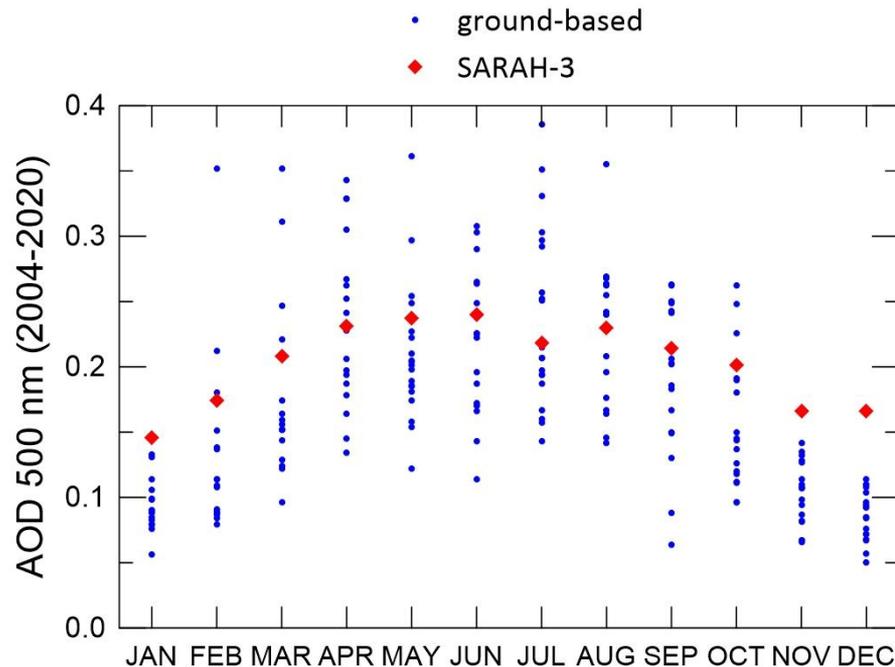


Global shortwave irradiance from satellite and comparison with surface measurements

EUMETSAT CM SAF SARA3 (Pfeifroth et al., 2018) from SEVIRI (0.05° spatial resolution), daily averages. Bias (-3.6 ± 10.2) Wm^{-2} or $(-1.2 \pm 7.1)\%$.



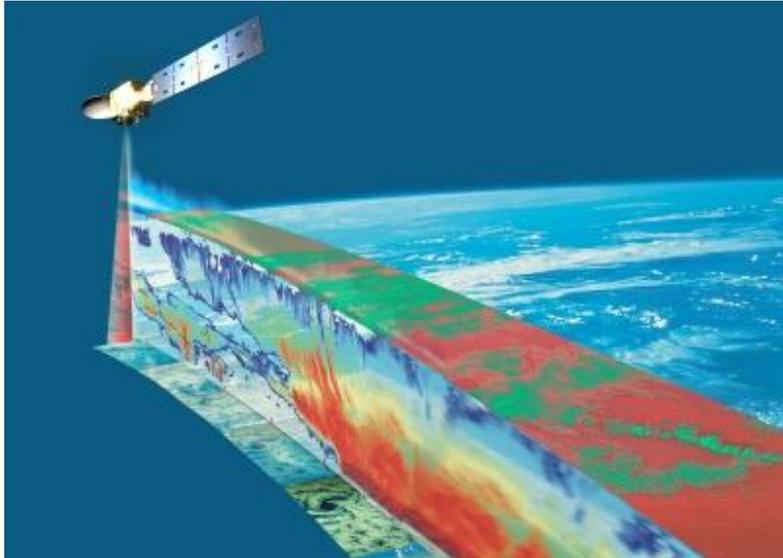
Role of the aerosol optical depth



In cloud-free days with desert dust the SARA3 irradiance overestimation can reach 8%.

Validation of EarthCARE products

ESA and JAXA **EarthCARE** (Cloud, Aerosol and Radiation Explorer) mission launched on 28 May 2024 will advance our understanding of the role of clouds and aerosols on the Earth's radiation budget.



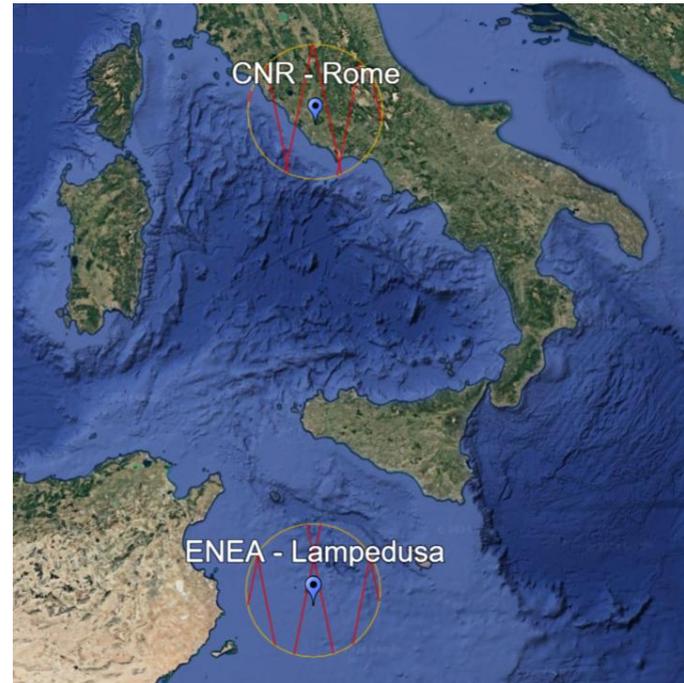
- The Atmospheric Lidar (**ATLID**) at 355 nm
- The Cloud Profiling Doppler Radar (**CPR**) at 94GHz
- The Multi-Spectral Imager (**MSI**) with 8 channels from visible to thermal infrared
- The Broad-Band Radiometer (**BBR**) with shortwave and longwave channels.

The EC-VALMED.it validation project

Contribution of the Italian observatories in the Central Mediterranean to the EC validation products during the commissioning phase, funded by ASI, coordinated by CNR-ISAC. Focus on L2 single (L2a) or multiple-sensor (L2b) products

Rome
Micro Rain Radar
Disdrometer
Wind lidar
SKYNET photometer
AERONET photometer
All sky camera
Raman-Mie-Rayleigh Lidar
C-band Doppler weather radar
CHM15k ceilometer

Lampedusa
MWR HATPRO RPG
Disdrometer
AERONET photometer
All sky camera
Raman-Mie-Rayleigh Lidar
Cloud Doppler Radar 35 GHz
CHM15k ceilometer



Validation of EC AOD products with photometer data

ATLID: AOD at 355 nm

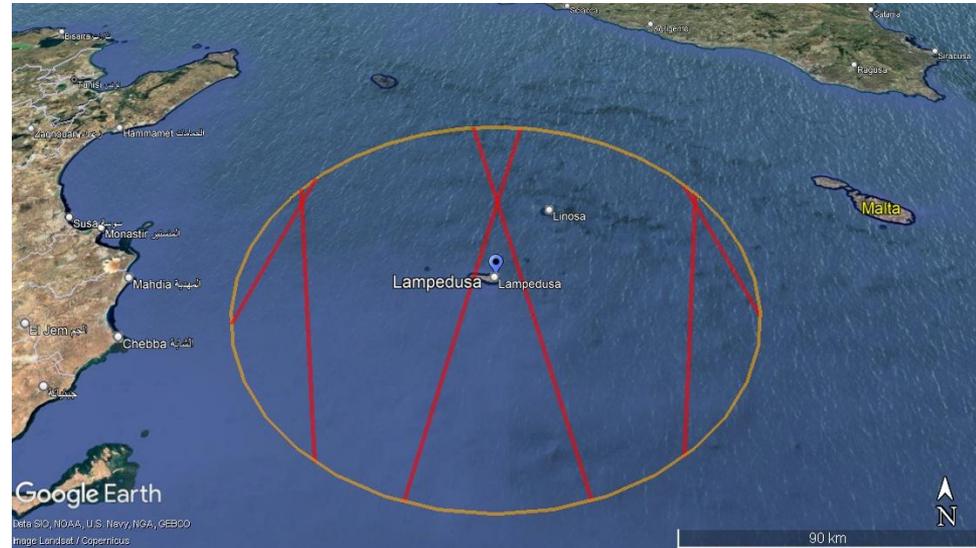
MSI: AOD at 670 nm over land and ocean, AOD at 875 nm over land

Relative orbit	Time (UT)	Nominal mid-swath distance (km)	EC AOD 355 nm (ATLID)	AERONET 355 nm	EC AOD 670 nm (MSI)	EC AOD 875 nm (MSI)	AERONET 670, 875 nm
78	00:51	71.6	X				X
117	13:28	8.8	X	X	X	X	X
218	00:47	10.7	X				X
257	13:24	73.5	X	X	X	X	X
358	00:44	92.8	X				X
366	13:32	91.0	X	X	X	X	X

The AOD validation can be performed only during daytime.

Spatial/temporal selection of data

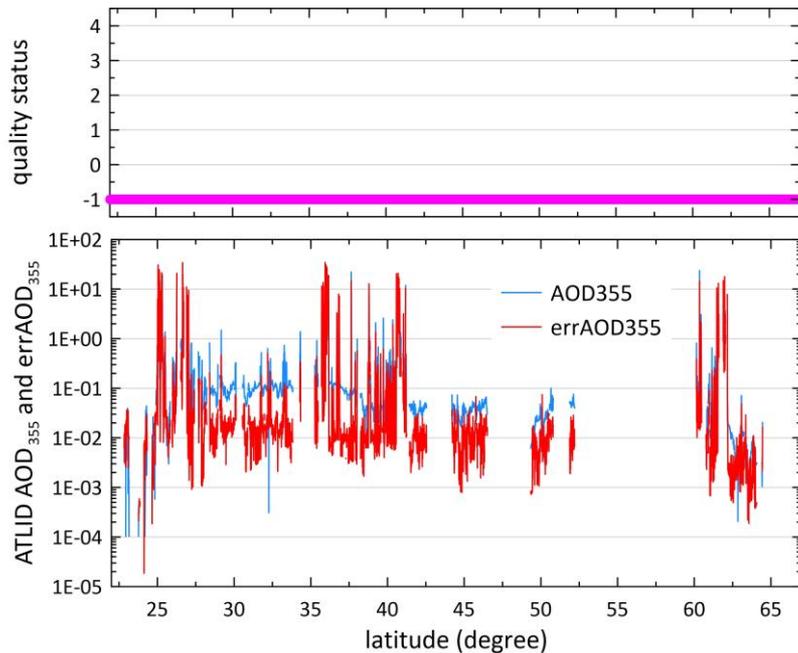
- ✓ What are the most suitable temporal/spatial intervals to use for comparing EarthCARE and ground-based measurements?
- ✓ Ground-based: ± 1 hour
- ✓ ATLID:
 - ± 2 s ($\sim \pm 7$ km)
 - ± 5 s ($\sim \pm 28$ km)
 - ± 10 s ($\sim \pm 56$ km)
- ✓ MSI:
 - ± 12 pixels (± 6 km)
 - ± 25 pixels (± 12.5 km)



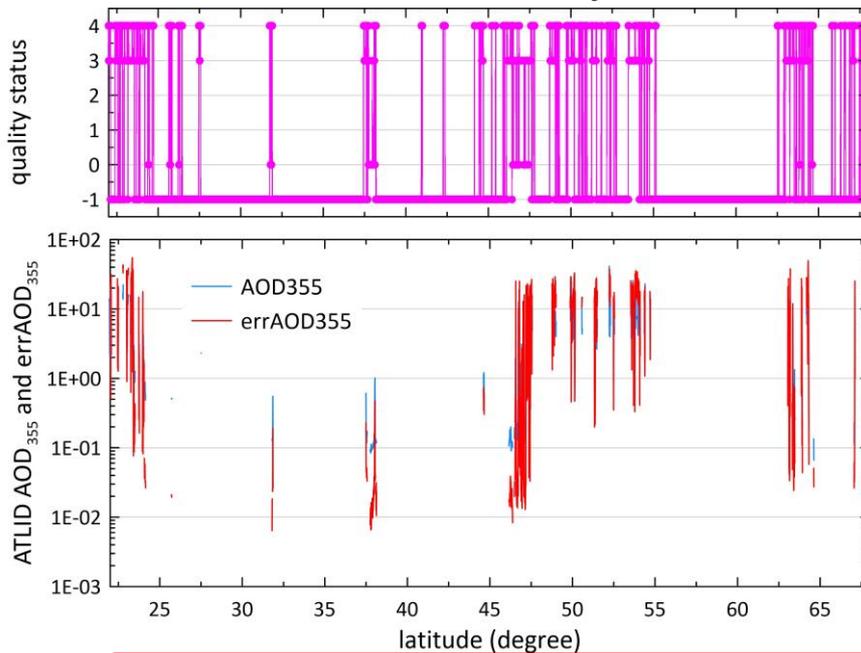
Development of a new methodology to select the satellite data based on the homogeneity of data from MSI (150 km swath width) over Lampedusa and along the ATLID/CPR tracks.

Validating the EC AOD at 355 nm (A-ALD from ATLID)

Baseline AC - 31 Dec 2024



Baseline AE - 30 May 2025



$Q_{ALD} = 0$, the data are of good quality.
 $Q_{ALD} = 1$, the data are valid, but the number of aerosol layers is higher than the configurable threshold.
 $Q_{ALD} = 2$, the data are valid, but the relative uncertainty of the mean backs. coeff. of at least one aerosol layer is larger than the configurable threshold.

$Q_{ALD} = 3$, warning that data are provided, but the A-TC product indicates a cloud in the profile.
 $Q_{ALD} = 4$, the (input) data are invalid.
 $Q_{ALD} = -1$ a cloud was detected in the profile.

Validating the EC AOD at 670 and 875 nm (from MSI)

Of the three daytime overpasses, only two have a MSI pixel including Lampedusa.

Selection of data whose AOD retrieval has been flagged as successfully converged, i.e. with quality status 0 and 1.

Most of the frames have invalid data, with quality status 3 or 4.

Only 3 cases (Jan-May 2025) match the selection criteria.

Quality status:

0: good/nominal quality, retrieval did converge;

1: quality may be degraded due to brighter than usually expected surface pixel for the dark target approach, retrieval did converge;

2: degraded quality, retrieval did not converge, but may still be usable;

3: no retrieval attempt due to inappropriate surface (i.e. snow, ice, desert etc.) or cloud presence for imager aerosol retrieval;

4: no retrieval attempt due to bad or missing input data (input data not available or out of bounds).

Results

		AOD 670 nm			AOD 875 nm		
Date	Min. distance (km)	AERONET	MSI 25X25	MSI 51X51	AERONET	MSI 25X25	MSI 51X51
25/01/2025 13:28 UT	0.25	0.067±0.009 (4)	0.09±0.02 (57)	0.09±0.02 (310)	0.059±0.008 (4)	0.07±0.02 (57)	0.07±0.02 (310)
19/02/2025 13:28 UT	0.11	0.09±0.03 (5)	0.18±0.01 (4)	0.13±0.03 (299)	0.08±0.03 (5)	0.14±0.01 (4)	0.11±0.03 (299)
16/03/2025 13:28 UT	0.24	0.071±0.007 (24)	-	0.08±0.02 (741)	0.064±0.007 (24)	-	0.07±0.01 (741)

Analysis of the atmospheric particulate effects on photovoltaic systems

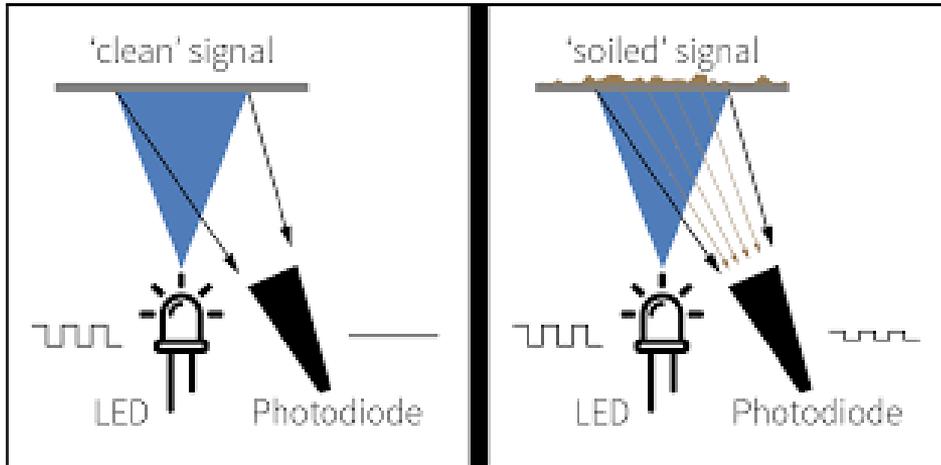


2017/03/30



Devices

Kipp&Zonen Dust IQ: transmission loss or soiling ratio (%) of nearby PV modules due to soiling



Devices

Campbell CR-PVS1: short circuit current of a solar module is directly proportional to the light intensity reaching the panels

$G_{eff,Test}$: effective irradiance of dirty panel
 $G_{eff,Ref}$: effective irradiance of clear panel

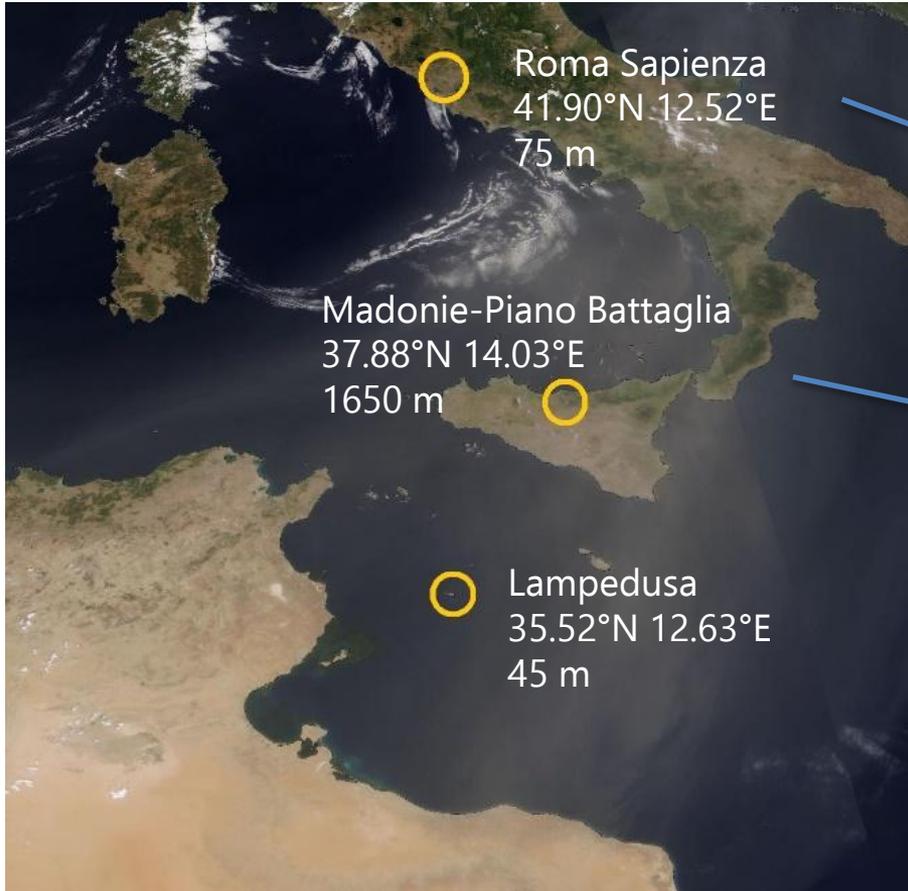
Soiling loss index (%) $SLI = \left(1 - \frac{G_{eff,Test}}{G_{eff,Ref}}\right) \times 100\%$



G_{eff} : effective irradiance

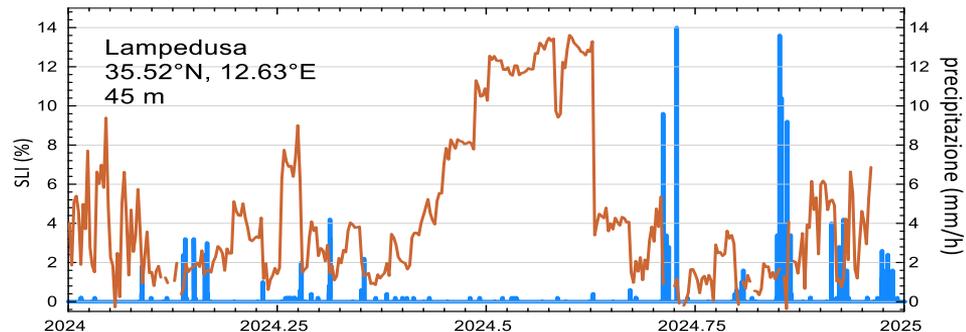
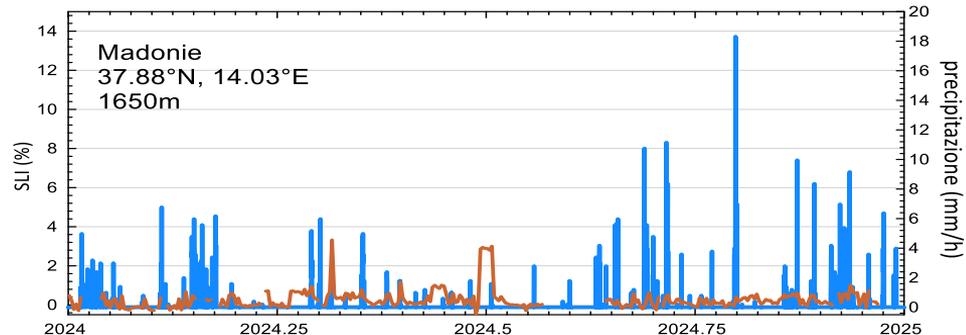
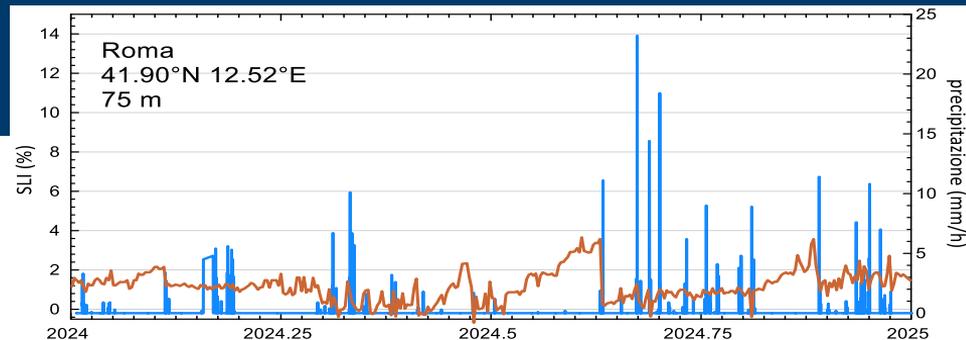
$$G_{eff} = I_{sc} \frac{[1 - \alpha(T - T_0)]}{I_{sc,STC}}$$

Similar devices installed at other two sites



Results: 2024

Site	SLI annual mean	Standard deviation
Roma	1.17 %	0.76%
Madonie-Piano Battaglia	0.26%	0.50%
Lampedusa	4.28%	3.93%
Lampedusa, summer	9.29%	3.58%



Thank you

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0101 0010 1101  
0001 0110 1110  
1101 0010 1101  
1111 1010 0000
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