Julian Gröbner[1*], Saulius Nevas[2], Kerstin Schwind[2], Salim Ferhat[1], and Luc Blarel[3]

Methods for SI-traceable calibrations of network radiometers from AERONET Europe

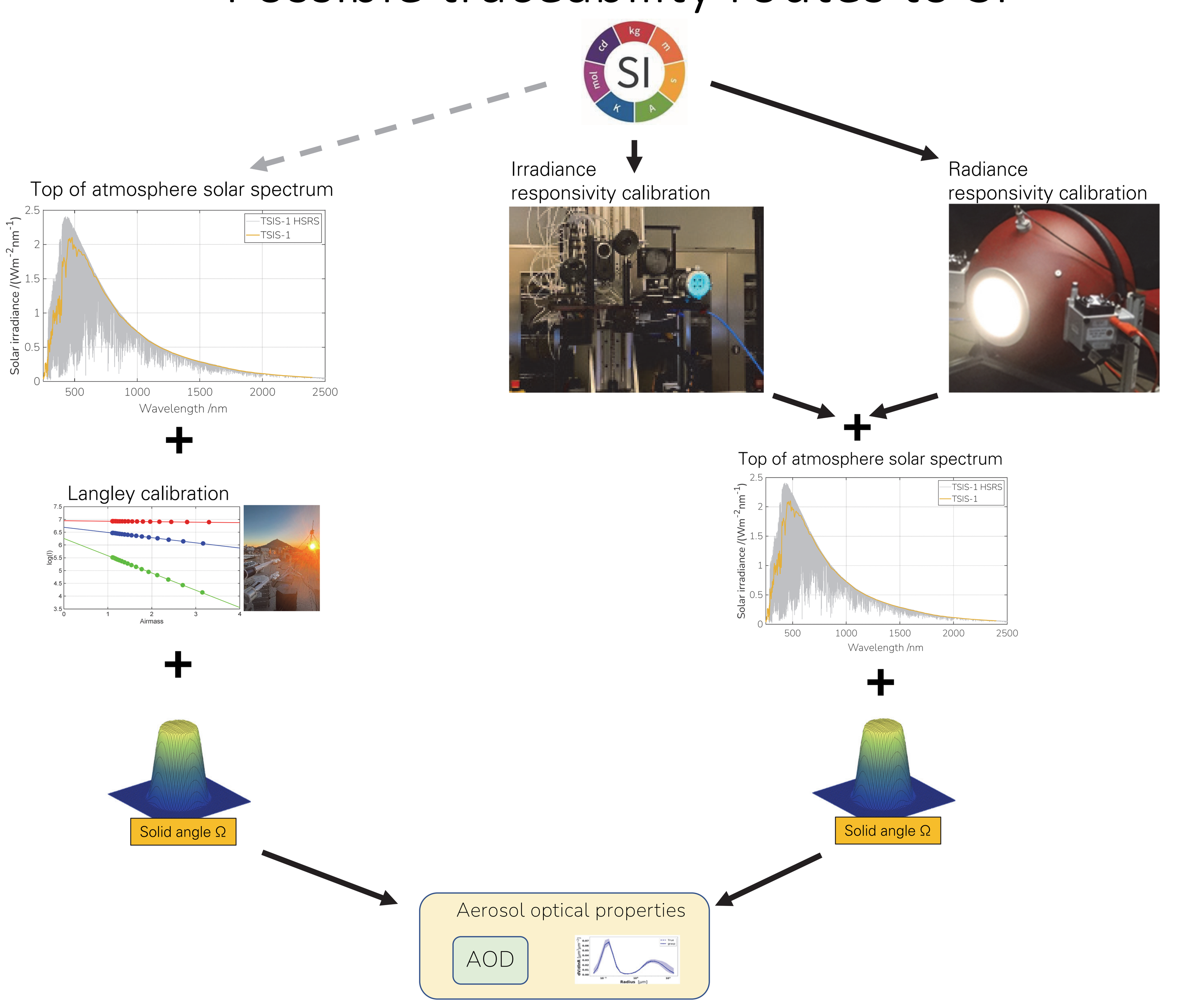
Introduction

Aerosol Optical Depth (AOD) retrieved from Si-traceable spectral solar irradiance measurements were shown to be fully consistent with the traditional Langley-based retrievals (Kouremeti et al., 2022, Gröbner et al., 2023).

In the project Metrology for Aerosol Optical Properties (MAPP), three calibration methods were tested to provide SI-traceable measurements of solar irradiance and sky radiance to retrieve aerosol optical properties:

1) Spectral irradiance responsivity calibration using a tuneable laser source and a calibrated reference detector. The radiance responsivity is derived from the irradiance responsivity using solid angle measurements of the field-of-view.
2) Radiance responsivity calibration using an integrating sphere source traceable to the SI and the relative responsivity functions of the sunphotometer channels. The irradiance responsivity is derived from the radiance responsivity and solid angle measurements.
3) ToA solar irradiances using Langley-plots, combined with a ToA solar spectral irradiance spectrum traceable to the SI (TSIS-1 HSRS). The radiance responsivity calibration is obtained through solid angle measurements of the sunphotometer.

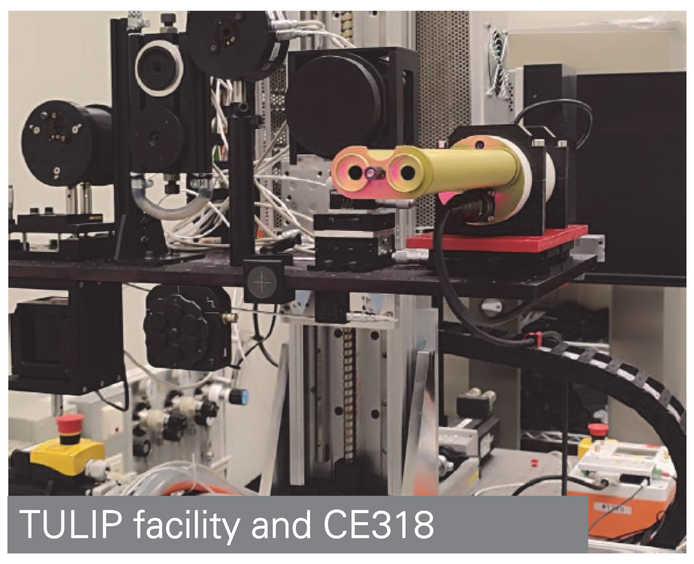
Possible traceability routes to SI



Radiometric calibration of CIMEL #1270.

Spectral irradiance responsivity calibration

R_i The TULIP facility (TUnable Lasers In Photometry) was used for the calibrations against a reference detector. As a source, it uses a laser system based on an optical parametric oscillator (OPO) operating in pulsed mode with a pulse length of 2.5 ps and a repetition rate of 80 MHz. The spectral irradiance responsivities of the spectral channels (Figure 1) were measured with expanded uncertainties from 0.3% at 500 nm to 0.9% at 1640 nm.



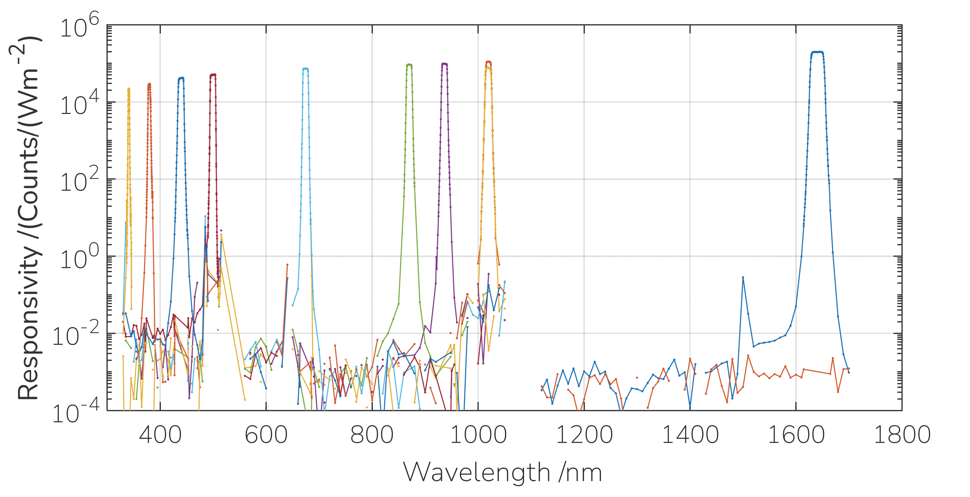


Figure 1.Spectral irradiance responsivities in counts/(Wm^{-2})

Field of view and solid angle characterisation

Ω_L The field of view was measured on a 2-D goniometer on a 1.5°x1.5° array with a resolution of 0.05°. The solid angle Ω_L was obtained by integrating the field of view measurements, $\Omega_L = \iint \mathrm{fov}(x,y)\partial x \partial y$

The expanded uncertainties of Ω_L range from about 0.5% at 1640 nm to 0.7% at 340 nm.

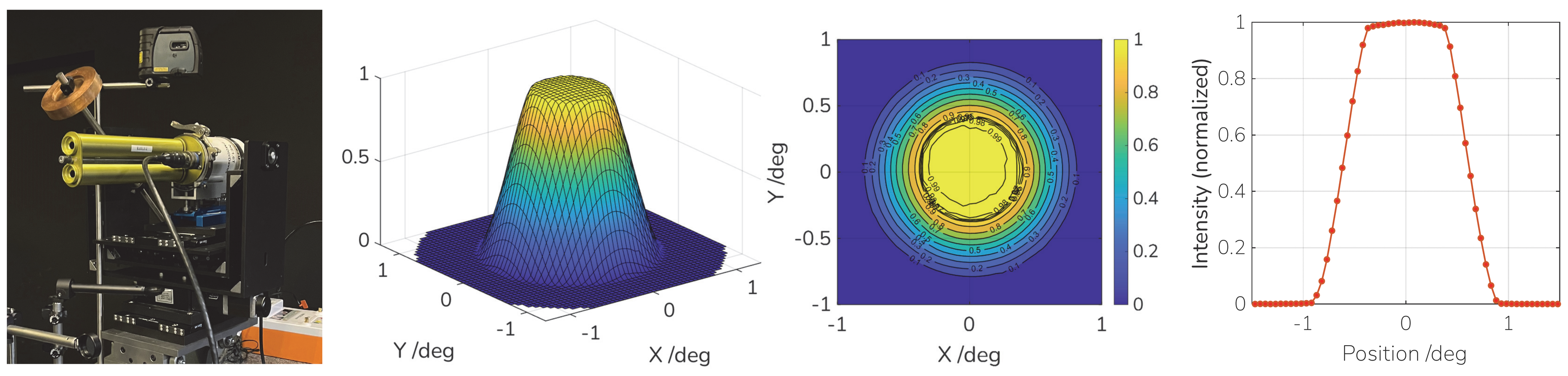


Figure 2. FOV at 500 nm. The full width at half maximum is 1.22° and the solid angle is 0.3785 msr.

Spectral radiance responsivity calibration

R_d The radiance calibration of the instrument was performed using an integrating sphere, with a calibration certificate traceable to the SI and obtained immediately prior to this comparison. The expanded uncertainties of the radiance calibration range from 0.5% at 1020 nm to 1.6% at 340 nm.

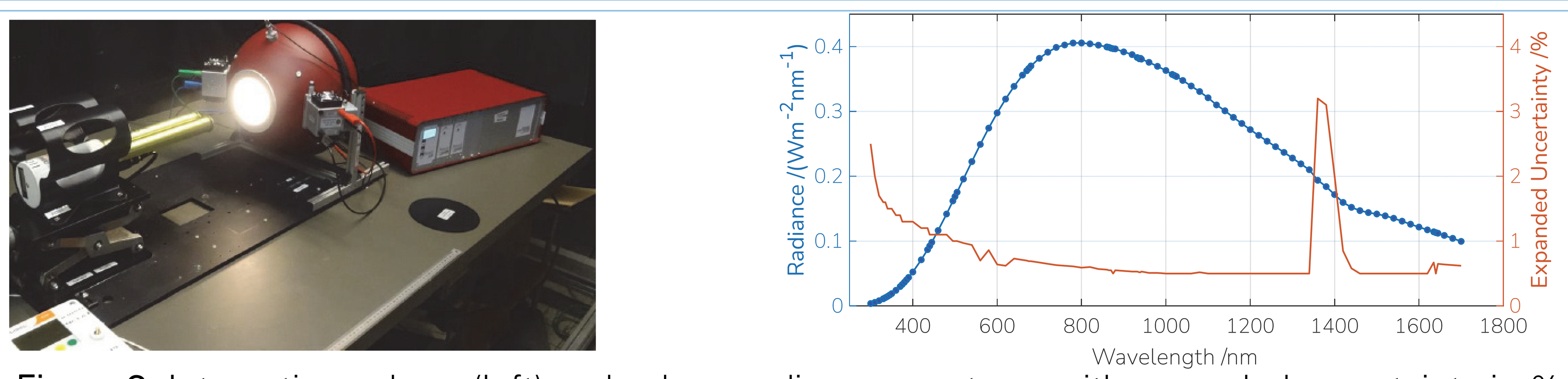


Figure 3. Integrating sphere (left) and sphere radiance spectrum with expanded uncertainty in %.

Results for CIMEL #1270

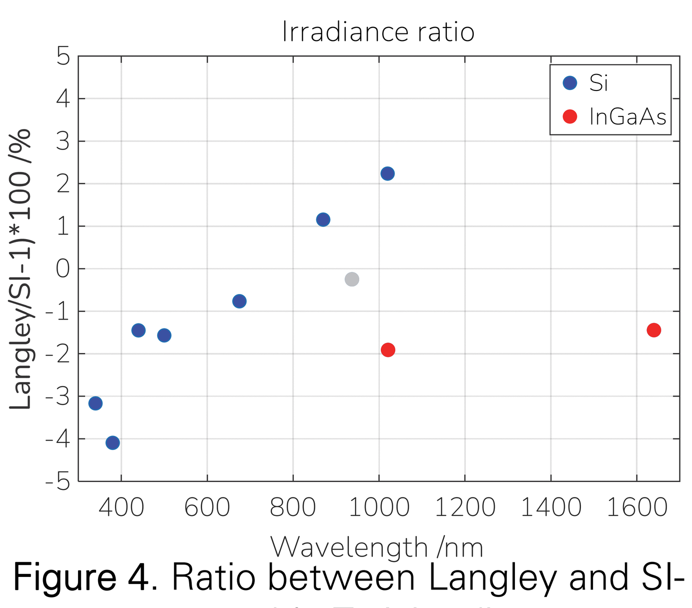


Figure 4. Ratio between Langley and SI-traceable ToA irradiances.

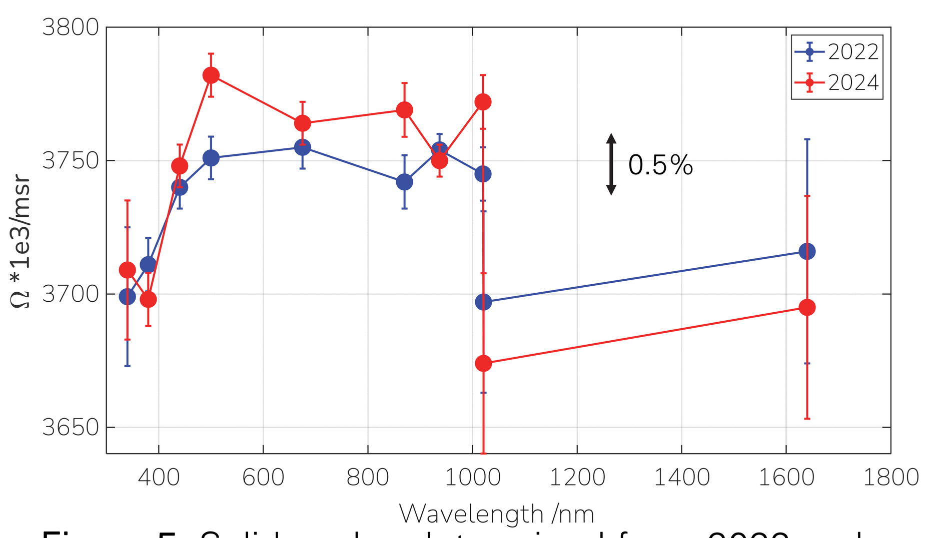


Figure 5. Solid angles determined from 2022 and 2024 measurements of Cimel #1270.

The irradiance and radiance responsivities R_i and R_d are related to the radiometric solid angle by the relation:

$$\Omega_R = \frac{R_d}{R_i}$$

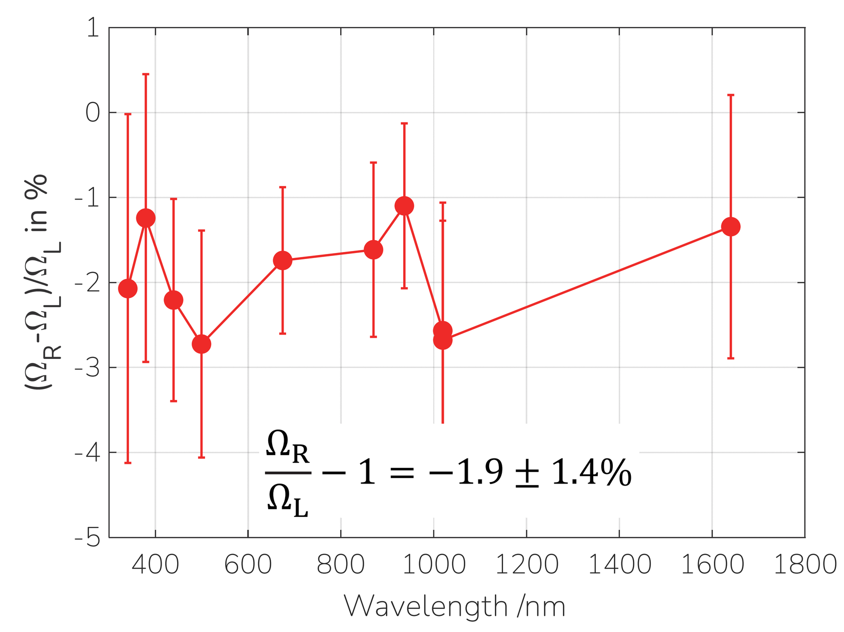


Figure 6. Ratio between Ω_R and Ω_L.

References

Kouremeti, N., Nevas, S., Kazadzis, S., Gröbner, J., Schneider, P., and K. M. Schwind, SI-traceable solar irradiance measurements for aerosol optical depth retrieval, Metrologia 59, 044001, https://doi.org/10.1088/1681-7575/ac6cbb, 2022.

Gröbner, J., et al., Spectral aerosol optical depth from SI-traceable spectral solar irradiance measurements, Atmos. Meas. Tech., 16, 4667–4680, https://doi.org/10.5194/amt-16-4667-2023, 2023

The work was carried out in the Joint Research Project Metrology for Aerosol Properties (MAPP), within the European Metrology Programme for Innovation and Research EMPIR, co-financed by EURAMET and the European Union H2020 programme.

Dorfstrasse 33, 7260 Davos Dorf, Switzerland
www.pmodwrc.ch

[1] Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center (PMOD/WRC), Davos, Switzerland.
[2] Physikalisch-Technische Bundesanstalt (PTB),, Braunschweig, Germany.
[3] University of Lille, LOA/CNRS, Lille, France.