Metrology for aerosol optical properties (MAPP): Project results and links with international aerosol field comparisons

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Atmospheric aerosols absorb or scatter solar radiation contributing the largest uncertainty to estimates and interpretations of climate change. Data for aerosol effects on sky radiation (e.g. **multi-wavelength Aerosol Optical Depth**) (**AOD**) is typically collected by optical radiometers which are largely **lacking traceability to the SI**. Currently, radiometer calibration is performed using artefacts with outdoor measurements at specific locations. SI traceable devices capable of on-site calibration would significantly speed up the calibration process, allowing more data to be obtained.

The **5th Filter Radiometer Comparison FRC-V** was held at Davos, Switzerland. Instrumentation belonging to different aerosol optical depth global networks have been invited, including the MAPP absolute calibrated PFR. The comparison took place at the premises of the Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center (PMOD/WRC) from September 27th to October 25th, 2021. **28 filter radiometers and spectroradiometers from 11 countries** have participated in this campaign. Instruments with **different calibration principles and methods** have been **compared with the WMO reference PFR-triad in terms of their AOD measurements**.

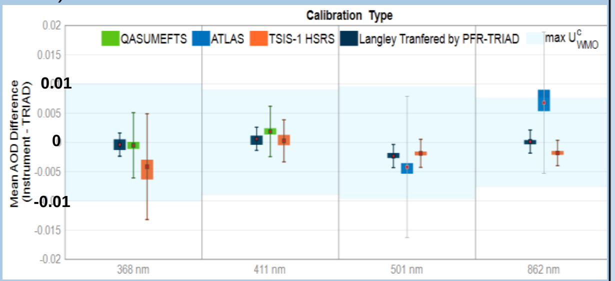
19ENV04 MAPP Metrology for aerosol optical properties

The EMRP project MAPP (2020-2023) is a collaboration of aerosol related research institutes and metrological institutes and aims to develop methods and SI-traceable devices for both laboratory and in-field calibrations of radiometers, measuring solar and lunar irradiance. Data on the measurement uncertainty for a range of aerosol optical properties, retrieved from remote sensing-based instruments will also be developed along with validated methods linking ground-based measurements to satellite-based data. At the end of the project in 2023 results obtained will help shorten the radiometer calibration chain, reduce the downtime of monitoring networks and generate traceable data to support societies in adapting to a changing climate.

SI-traceable solar irradiance measurements for aerosol optical depth

Current Calibration techniques include the **Langley calibration method** that requires outdoor measurements under constant aerosol conditions. In addition, the WMO has assigned PMODWRC to act as a **reference for AOD operating a reference triad of PFR sun-photometers**.

During MAPP (Kouremeti et al., 2022) a PFR has been characterized and calibrated at state-of-the-art calibration facilities of PTB. In order to retrieve AOD from absolute calibrated irradiances three state-of-the-art top-of-the-atmosphere (TOA) solar spectra have been used (**QASUME-FTS**, **ATLAS**, **TSIS-1 HSRS**).



Left figure: Panels for the four PFR channels showing the median AOD differences of the absolute calibration and Langley methods, compared to the WMO reference PFR Triad. The colored squares represent the 5th and 95th percentile of the differences, while the error bars represent the expanded uncertainty U (k=2). The light blue area represents the WMO criterion.

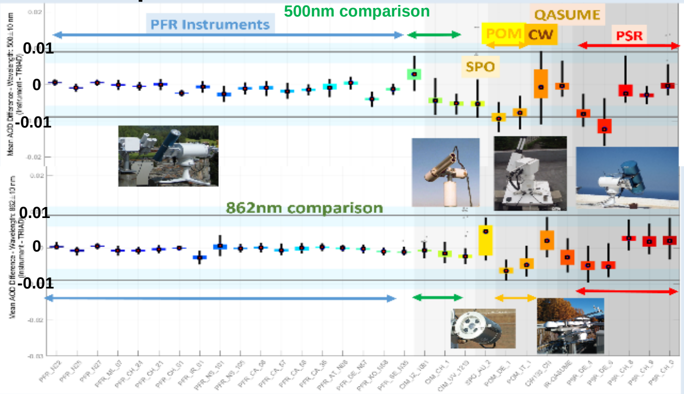
The new Calibration factors agreed within ±0.57 % (3σ) using all three TOA spectra except for 368 nm (-1.1%) and 862 nm (1.8%) channels for one out of the three TOA spectra. **The work provides a first step on opening a new era of AOD measurements traceability, providing a link to the SI through a laboratory-based approach, with main advantages being the low uncertainty, the possibility of enhancing global AOD homogenization efforts and the chance to avoid calibration activities based on instrument relocations.**

The 5th Filter Radiometer Comparison FRC-V

The objective of this campaign was to compare different instruments belonging to different global or national networks in order to quantify the main factors that are responsible from possible deviations. The whole activity aims to a **homogenization of the Aerosol Optical Depth (AOD) measurements in a global scale**.

field measurements at Davos

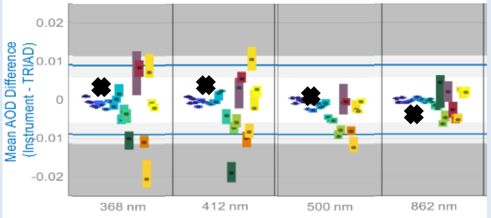
AOD comparison with the WMO reference



Left figure: Panels for the 500nm and 862nm PFR channels showing the median AOD differences of all instruments compared to the WMO reference PFR Triad. The colors indicate different instruments The grey limits represents the WMO criterion for AOD traceability.

Left down figure: Comparison statistics of AOD differences with the WMO reference grouped in instrument types. Right: Instrument differences in various wavelength including the absolute (MAPP) calibrated PFR instrument (black crosses).

Instrument (num. of instr.)	368nm		412nm		500nm		862nm	
	Diff*10-3	CC	Diff*10-3	CC	Diff*10-3	CC	Diff*10-3	CC
PFR (14)	-1±1	0.999	1±1	0.999	1±1	0.999	1±0	0.998
CIMEL (3)	-4±4	0.995	-4±2	0.993	-5±1	0.997	-2±3	0.991
POM (2)			-6±3	0.990	-8±2	0.996	-5±2	0.970
PSR (6)	-6±3	0.994	-3±4	0.990	-5±2	0.995	-1±2	0.977
QASUME (1)	8±6	0.943	5±3	0.940	0±2	0.968		
SPO (1)	-10±3	0.988	-19±4	0.985			4±4	0.948
CW (1)	8±3	0.943	3±5	0.972	-1±5	0.931	2±3	0.787
ALL (28)	-2±3	0.988	-2±3	0.988	-2±1	0.992	1±3	0.980



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