Non-ionizing Radiation Surveillance 1/7035/2019

16.4.2019

Calibration Certificate

Customer	University of Helsinki Faculty of Biological and Environmental Sciences Organismal and Evolutionary Biology P.O. Box 65 00014 University of Helsinki
Contact person	Matt Robson
Calibrated instrument	Ocean Optics Maya 2000 Pro Spectroradiometer [1] sn MAYP11278 with Bentham D7 H SMA diffuser sn 12321 and fibre QP400-2-SR-BX, 00S-004728-16
Date of calibration	12.4.2019
Calibration personnel	Lasse Ylianttila and Antti Latomäki

Senior Scientist

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[1] These results apply only to the devices mentioned above. The certificate may not be reproduced partially, except with prior approval of STUK.

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Wavelength calibration

Wavelength calibration was done using a Oriel 6036 Hg(A) low pressure Hg lamp. The lamp spectrum contains both Mercury (Hg) and Argon (A) emission lines. In the Maya spectrum the dark signal was subtracted before the wavelength scale was calibrated. For the wavelength calibration the quasi-Gaussian fitting method described in [1] was used.

In the table 1 the wavelength calibration results are given for different Hg and A emission lines. The lines used for wavelength calibration are marked in bold. In the table 2 are the new wavelength scale coefficients. This wavelength scale was used in the calibration and it is used in the *Maya_P_calibration_2019_MAYP11278.xlsx* file. The wavelength change from the 2016 calibration was significant and new wavelength coefficients were calculated. The new wavelength scale coefficients were saved to the Maya spectroradiometer's memory. The wavelength values used in the Excel-files are the wavelength values calculated by the Ocean Optics software using the new wavelength scale coefficients.

Table 1. Hg and A emission lines

Emission line [nm]	**Type of line**	**Wavelength difference after the calibration [nm]**	***Wavelength difference before the calibration [nm], from fitting values***
Mercury			
253.65	**single**	**0.02**	***0.12***
296.73	**single**	**0.03**	***0.15***
302.18	double	0.03	*0.18*
312.96	**triple**	**0.01**	***0.13***
334.15	single	0.32	*0.32*
365.14	**triple**	**0.05**	***0.17***
404.66	**single**	**0.07**	***0.18***
435.83	single	0.03	*0.13*
546.08	**single**	**-0.03**	***0.11***
576.96 & 579.07	double	0.08	*0.23*
1013.98	**single**	**-0.30**	***-0.30***
Argon			
696.54	single	0.12	*0.28*
763.51	**single**	**0.09**	***0.25***
826.45	**single**	**0.00**	***0.16***
852.15	single	-0.06	*0.11*

Table 2. Wavelength scale coefficients. New coefficients from the 2019 calibration.

Coefficient	Value
third	-1.55808 e-9
second	-1.03225 e-5
first	0.477559
intercept	187.688

Irradiance calibration

The calibration was done by using 1000 W FEL lamp and Deuterium lamp for the wave-length range 250 – 900 nm. The FEL lamp used was BN-9101-165 and the Deuterium lamp was UV-653. The FEL lamp was used for the primary calibration. To improve the signal/noise ratio at the UV wavelengths the Deuterium lamp was used for the calibration in the wavelengths below 350 nm. The Deuterium lamp was used as a relative source. The calibration factors obtained from the Deuterium lamp measurement were fitted to the calibration factors obtained from the FEL measurements at the wavelength range of 330 – 370 nm. A more detailed description of the calibration method is in [1].

For the Maya spectroradiometer the dark signal was subtracted from the measurement signal and corrections for the linearity and stray light were applied to the raw data before calibration spectrum was calculated. The calibration spectrum is presented in the figure 2. The calibration spectrum is calculated in the file *Maya_P_calibration_2019_MAYP11278.xlsx*. This file was stored to the customers computer during the calibration.

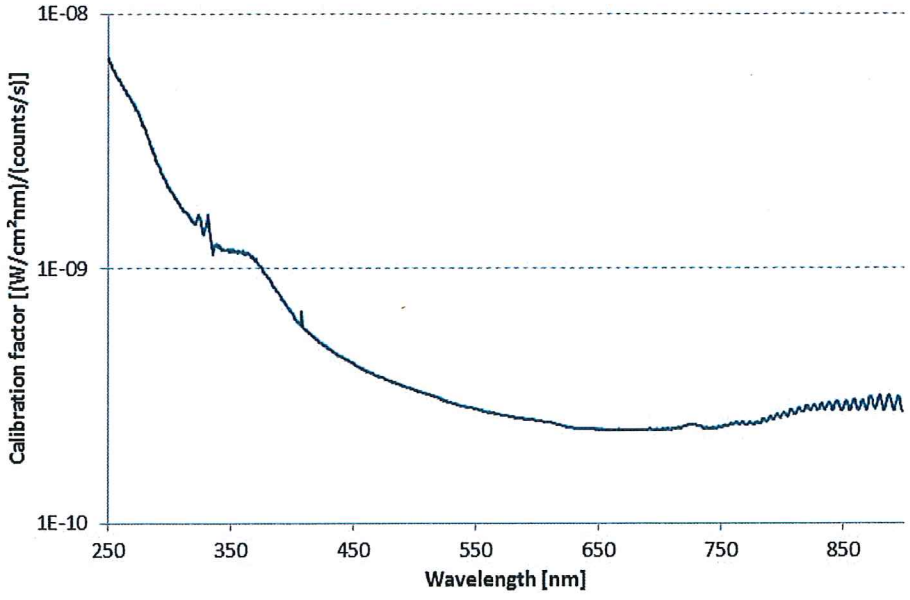

Figure 2. the calibration spectrum

General Notes

The calibration measurements were done using a polycarbonate sheet as a UV-blocking filter. The polycarbonate filter is specially made for these calibrations.

Traceability and uncertainty

The FEL lamp BN-9101-165 has been calibrated at the Metrology Research Institute of the Helsinki University of Technology (T-R 387). The wavelength range of the calibration is 290 – 900 nm.

The Deuterium lamp UV-653 has been calibrated at STUK by STUK's reference spectroradiometer Bentham DM-150 at the same distance as the calibration measurements were made. The calibration of the Deuterium lamp is traceable to NIST via lamp FEL-434.

The uncertainties of the calibration at different wavelengths are given in table 3. The uncertainties are given with coverage factor k = 2.

Table 3. The calibration uncertainty for Maya spectroradiometer

Wavelength	Uncertainty [%] coverage factor k = 2
300 nm	3.9
350 nm	1.9
400 nm	1.8
600 nm	1.4
900 nm	1.4

References

[1] Ylianttila, L., R. Visuri, L. Huurto, and K. Jokela, (2005) Evaluation of a single-monochromator diode array spectroradiometer for sunbed UV-radiation measurements, Phochemistry and Photobiology, 81, 333-341