



Aalto University
School of Electrical
Engineering

Out-of-range stray light and NiSO₄ filter characterization of single- monochromator Brewers

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1. Out-of-range stray light measurements
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EMRP

European Metrology Research Programme
► Programme of EURAMET

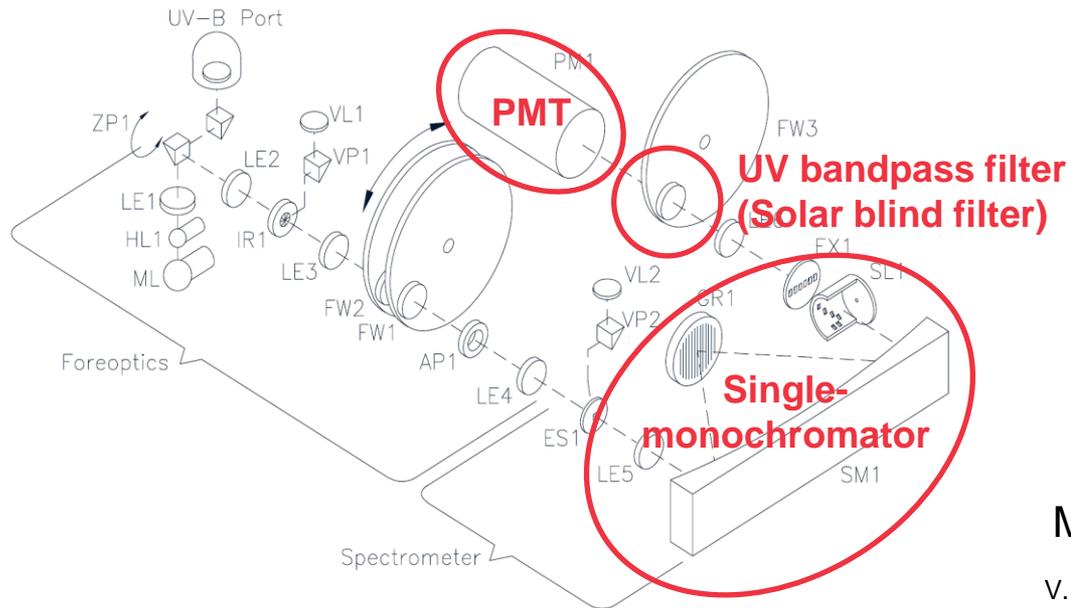


The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

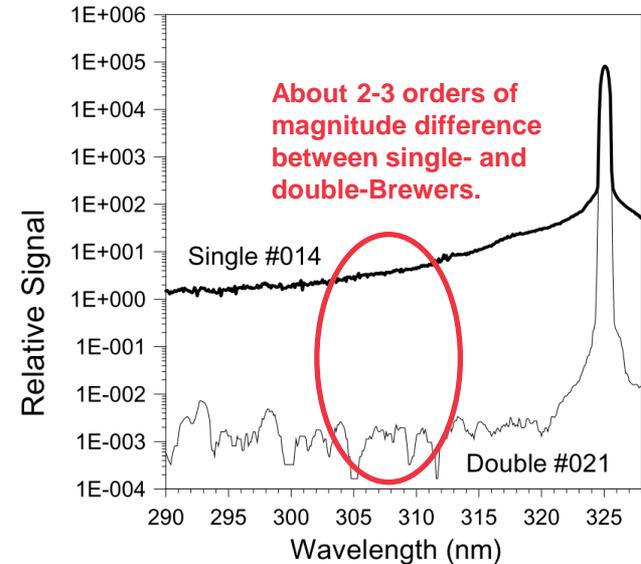
This work has been supported by the European Metrology Research Programme (EMRP) within the joint research project EMRP ENV59 Atmoz "Traceability for atmospheric total column ozone."

Background

Stray light



Brewer MKIV Spectrophotometer Operator's Manual



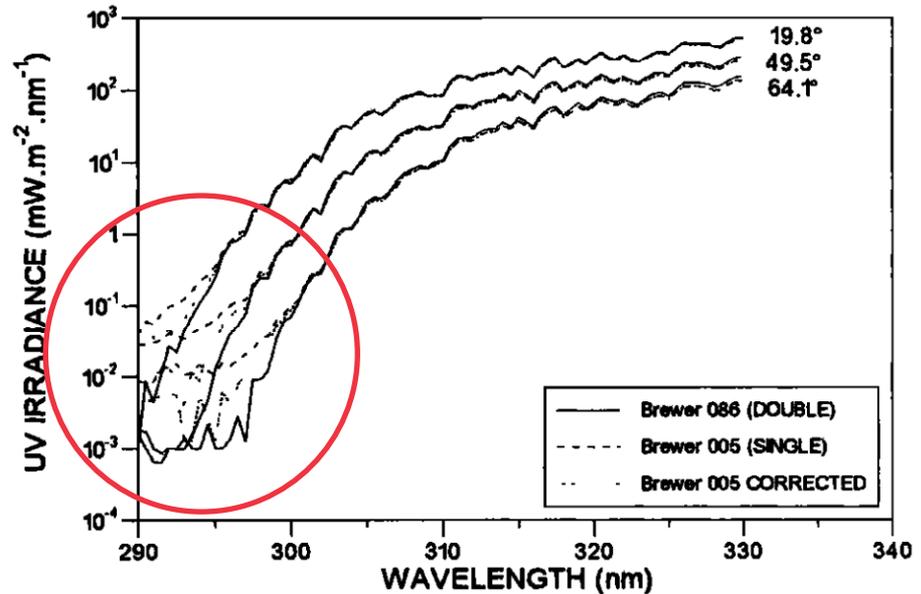
Measurement of HeCd laser at 325 nm

V. Fioletov, J. Kerr, D. Wardle, and E. Wu, "Correction of stray light for the Brewer single monochromator," *Proc. Quadrennial Ozone Symposium*, Sapporo, Japan, 369–370 (2000).

Background

Stray light

- Differences between single- and double-monochromator Brewer results at short wavelengths.
- Some differences even after *in-range* stray light correction.
- Measurement range stops at about 340 nm.
- How about *out-of-range* stray light?
 - *Higher irradiance level* in visible than in UV region.



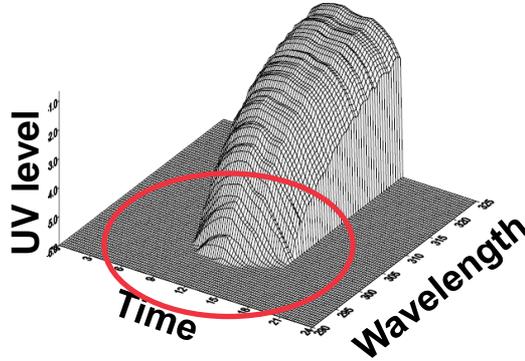
A. Bais, C. Zerefos, and C. McElroy, "Solar UVB measurements with the double- and single-monochromator Brewer ozone spectrophotometers," *Geophys. Res. Lett.* **23**, 833–836 (1996).

Background

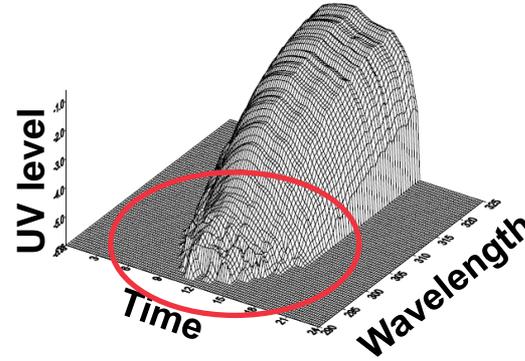
Stray light

V. Fioletov, J. Kerr, D. Wardle, and E. Wu, "Correction of stray light for the Brewer single monochromator," *Proc. Quadrennial Ozone Symposium*, Sapporo, Japan, 369–370 (2000).

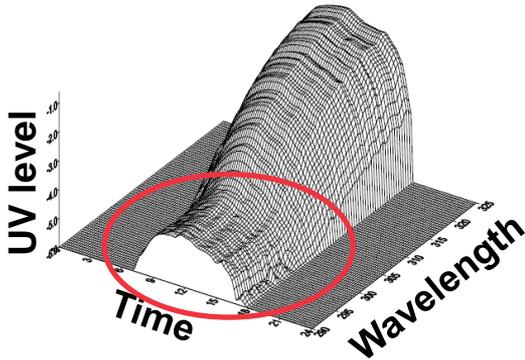
Double
Brewer



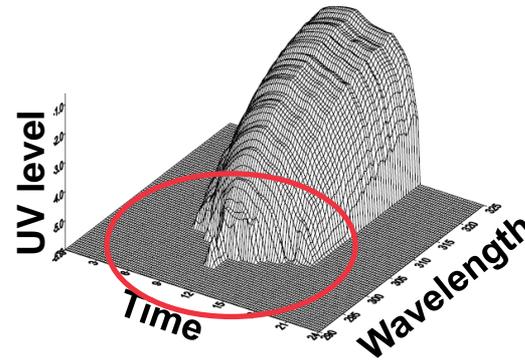
Single
Brewer
5 wavelength
correction



Single
Brewer



Single
Brewer
325 nm laser
correction



A?

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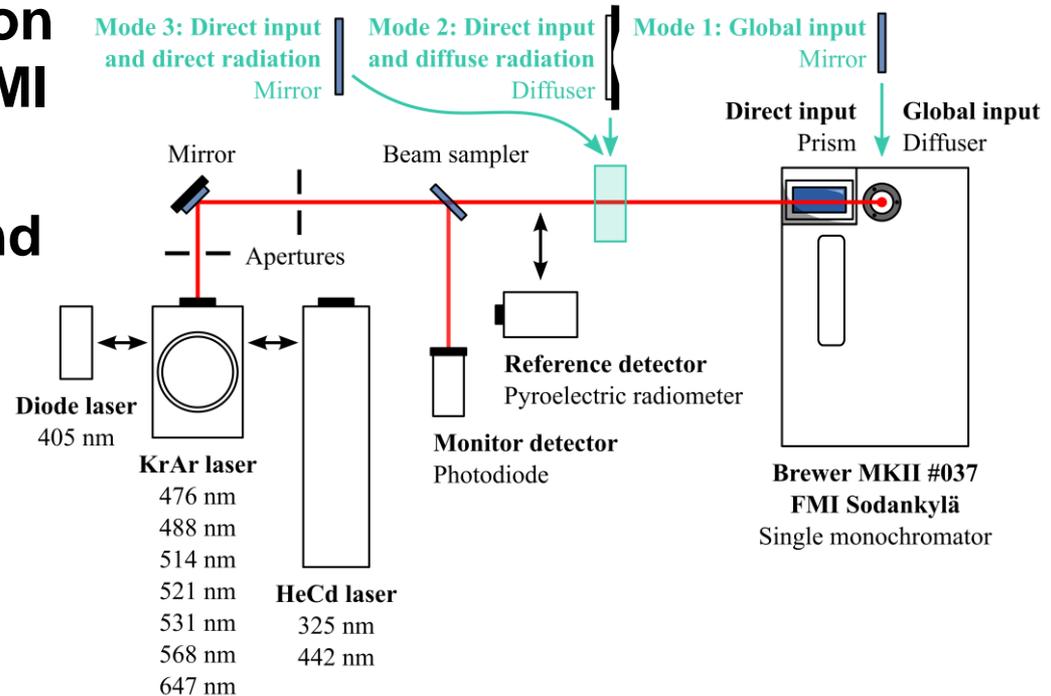
Measurement results

The image shows two individuals in dark winter clothing and hats working on a snowy rooftop. They are surrounded by various scientific instruments, including a large white cabinet, a tripod-mounted device, and other electronic equipment. The background features a dense forest of evergreen trees under a clear sky, suggesting a cold, outdoor environment. The text 'Measurement results' is overlaid in large white font across the center of the image.

Stray light measurement of FMI Brewer

Measurement setup

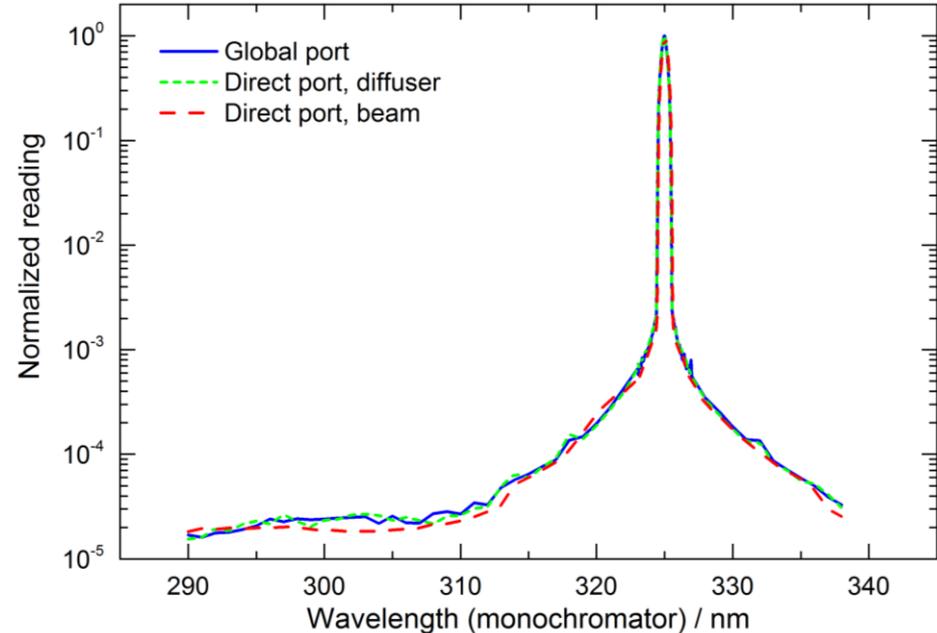
- Stray light characterization of Brewer MKII #037 of FMI in Sodankylä.
- One in-range (325 nm) and multiple out-of-range wavelengths.
- Different input ports utilized.



Stray light measurement of FMI Brewer

In-range stray light

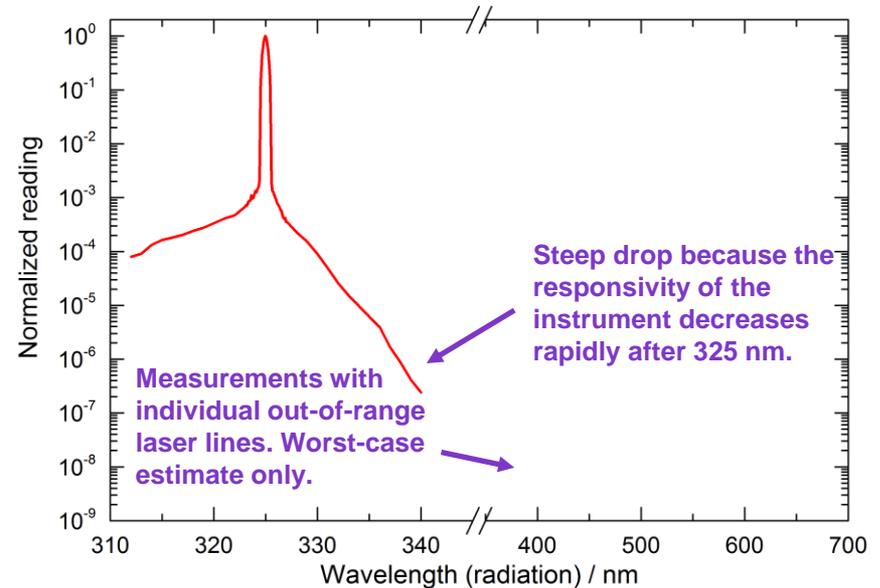
- *Fixed laser line* at 325 nm contributes to the signal at other monochromator positions.
- How does radiation at different wavelengths contribute to the signal at a fixed monochromator position?
- Flip the figure and take into account the spectral responsivity of the instrument.



Stray light measurement of FMI Brewer

In- and out-of-range stray light

- *Fixed monochromator position* at 325 nm sees contribution from other wavelengths.
- Part of the stray light profile can be determined from the measurement at 325 nm.
- Assuming that slit scattering function retains its shape in-band.
- No detectable signal with out-of-range lasers, i.e. limited by the noise floor of the measurement.
- Worst-case estimates!

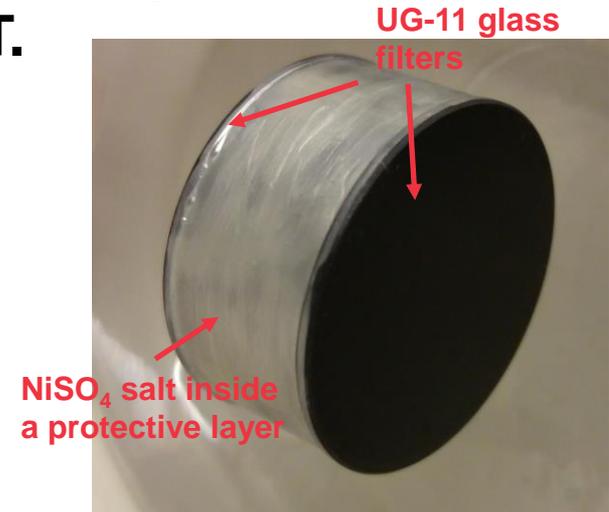


Solar blind filter characterization

Background

- Solar blind filter consists of a NiSO_4 piece sandwiched between UG-11 glass filters.
- Used in single-monochromator Brewers to prevent out-of-range radiation from entering the PMT.
- Questions:
 1. Are there any leaks in the stopband?
 2. What happens when the filters age?

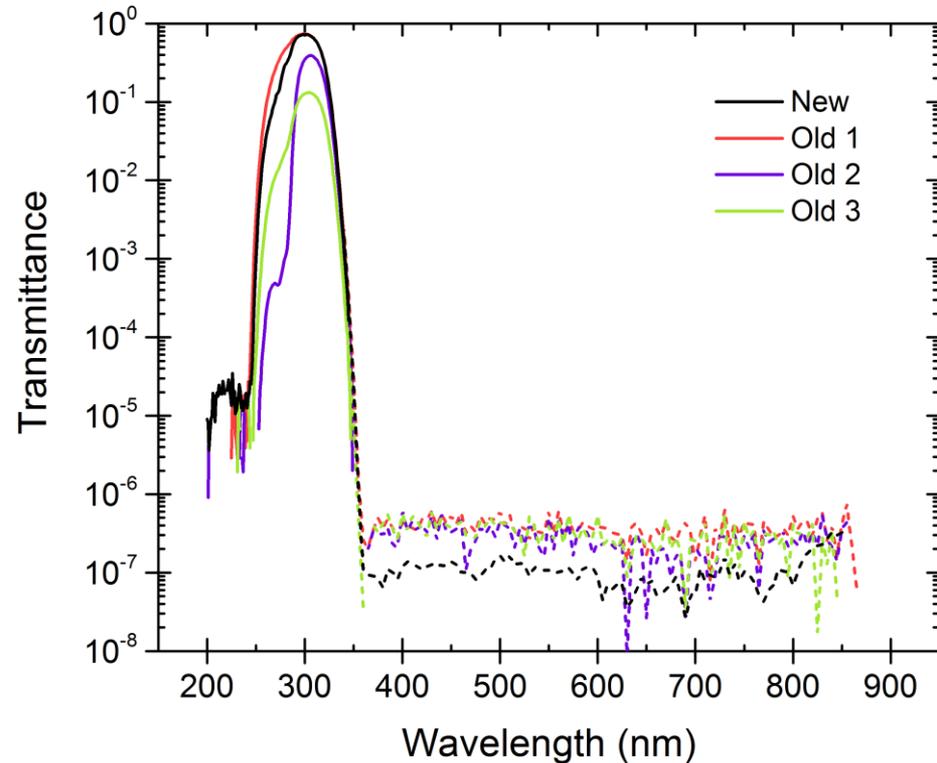
(Thanks to Kipp & Zonen and AEMET for providing the samples.)



Solar blind filter characterization

Spectral transmittance

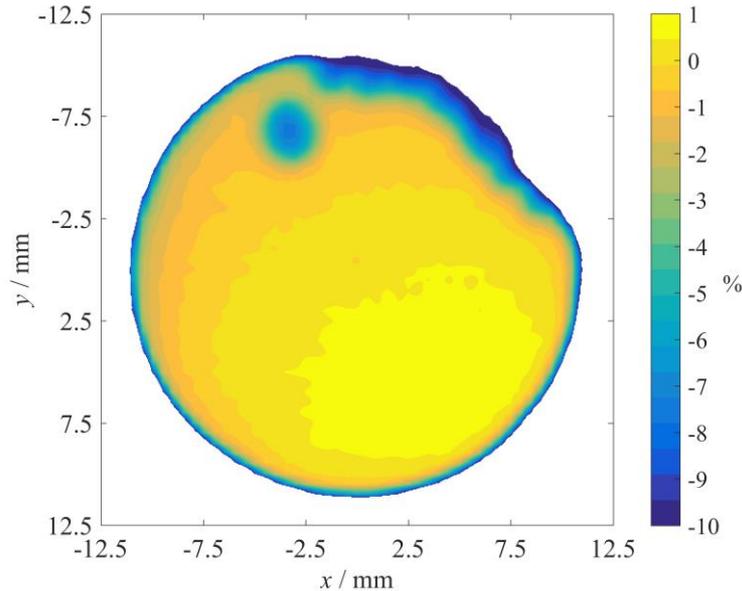
- Measured using a spectrophotometer.
- *No leaks in the stopband*, i.e. noise limited.
- Differences in the shapes of the pass- and transition bands between different filters.



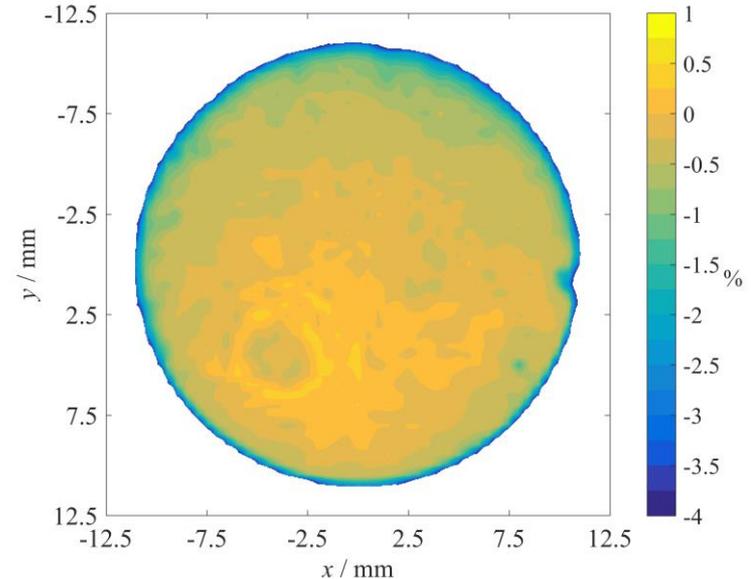
Solar blind filter characterization

Spatial uniformity of transmittance

Measured by scanning the surface with HeCd laser at 325 nm.



New sample

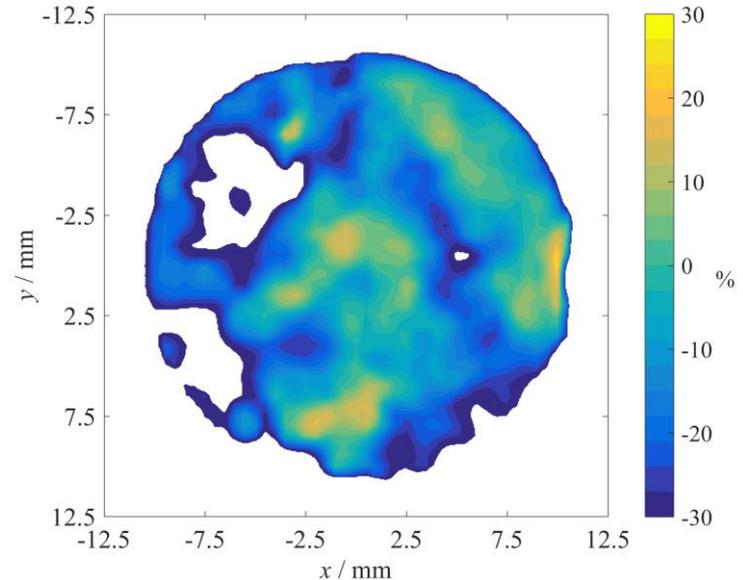
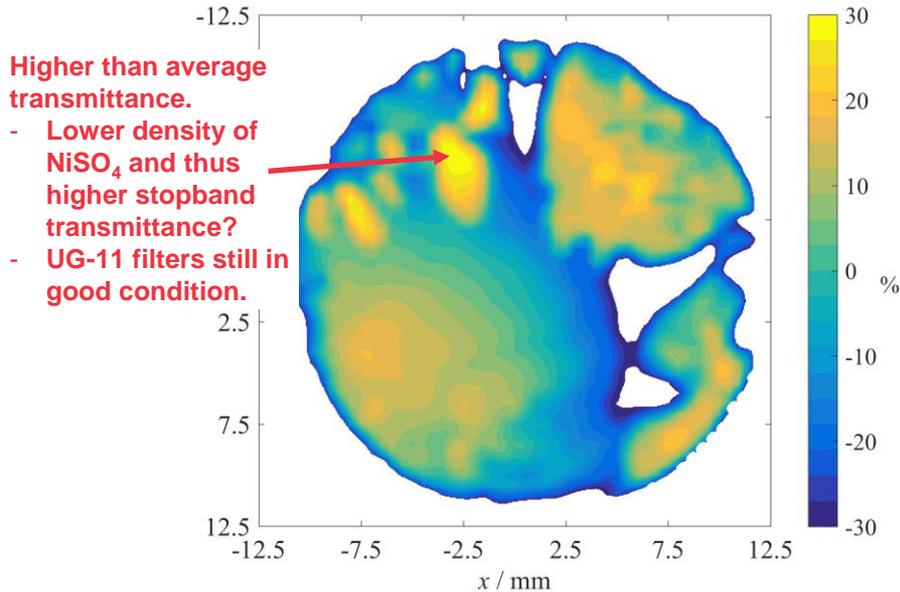


Old sample

Solar blind filter characterization

Spatial uniformity of transmittance

Measured by scanning the surface with HeCd laser at 325 nm.



Stray light analysis



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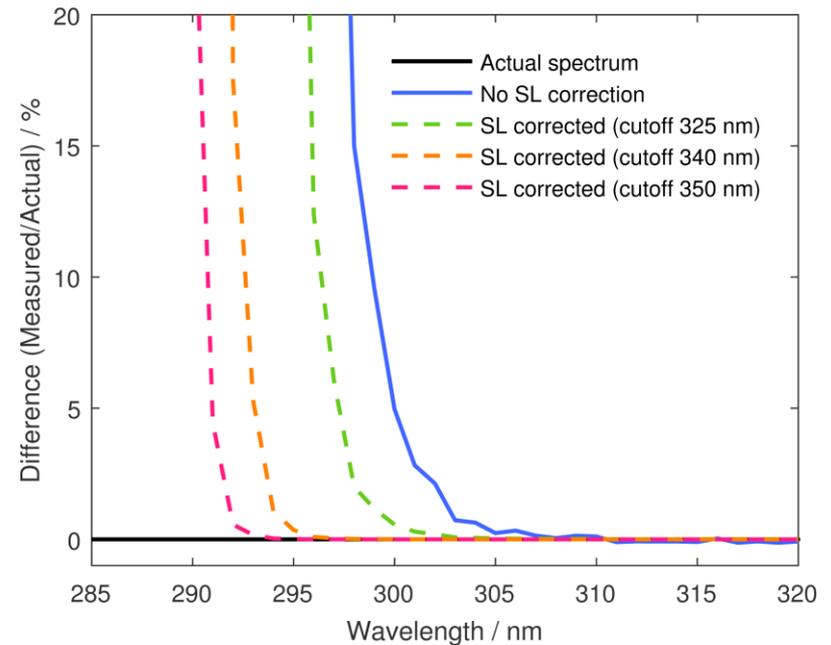
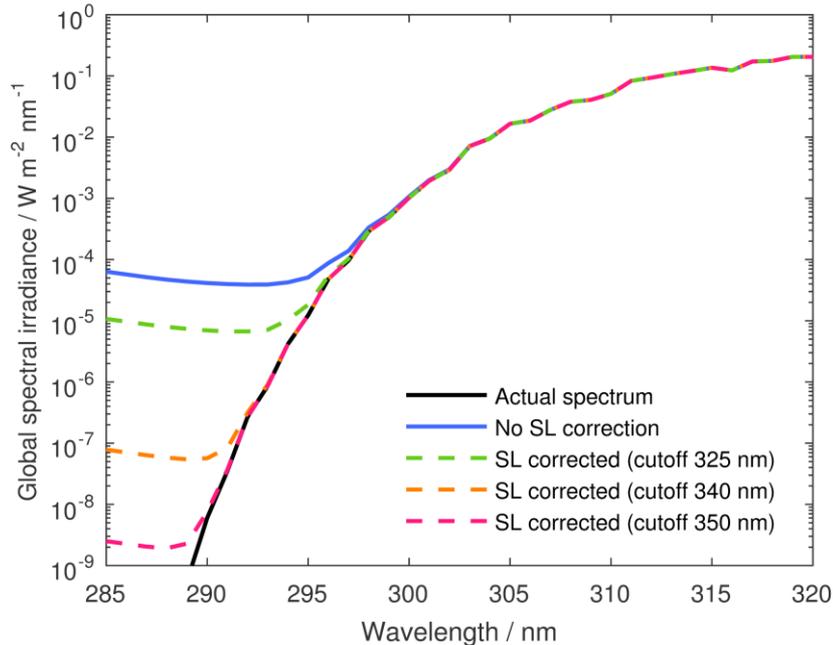
Stray light analysis

Parameters and assumptions

- How much of the stray light we can we get rid of when we extent the stray light correction to 325 nm, 340 nm and 350 nm?
- Instrument parameters
 - **Slit scattering function:** 325-nm HeCd measurement
 - Assumption: retains its shape at other wavelengths. Constant base-level of $2 \cdot 10^{-5}$.
 - **Responsivity of the instrument (UV and visible):** Combination of a typical PMT responsivity and the measured filter transmittance (with worst-case stopband transmittance).
 - Ignores the effect of other optical components.
- Sources
 - **Measured spectrum:** Typical solar spectrum (AM1.5)
 - **Calibration source:** Tungsten filament lamp.

Stray light analysis

Effect of in- and out-of-range light



Measured irradiance spectrum

- With and without stray light correction
- Effect of stray light correction cutoff (deconvolution limit)

Difference between measured (+corrected) signal and the actual spectrum

Conclusions

- **Out-of-range stray light properties of single-monochromator Brewers measured and analyzed.**
 - Out-of-range stray light itself should not be an issue.
- **Careful stray light analysis in the passband required.**
 - Transition band (325–350 nm) still affects the stray light correction to some extent.
 - Open question: Does slit scattering function retain its shape in the passband?
- **Solar blind filters may exhibit large spatial nonuniformity.**
 - NiSO_4 (salt) absorbs humidity? → Areas of high and low NiSO_4 density
 - Possible stopband leaks in areas with low NiSO_4 density?