

Cosine correction of Brewer UV measurements

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OMI (Ozone Monitoring Instrument) satellite UV product - PI of this product

- OMI onboard NASA's Aura spacecraft, Dutch-Finnish contribution
- continues TOMS record on ozone and UV
- available since 2004

Copernicus Atmosphere **Monitoring Service UV forecasts:** www.gmes-atmosphere.eu





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Part of this study was done during the EUBREWNET STSM of K. Lakkala, AEMET, March 3.-9., 2015



Motivation

• Results from the UV comparison in El Arenosillo in 2015

Only 5 out of 18 Brewer spectrophotometers are within \pm 5% of the QASUME reference, while 6 Brewers are outside of the 10% band.

Most Brewers had significant diurnal variations due to uncorrected temperature and angular response problems.



What happens if we use the FMI method for cosine correction?





Figure copied from the report of the campaign (J. Gröbner 2015). Average ratios from the whole campaign to QASUME using the calibrations from the instrument operators.

RBCC-E 2015 - Original Calibrations

Cosine correction method

- Developed by A. Arola, described in Lakkala et al. 2008.
- In operative use to corrected FMI's Brewer data
- NRT UV processing
- post processing of UV time series

Correction factor for the angular response of a spectroradiometer:

$$c_{glob} = F_{glob} / F'_{glob}$$
, where

$$F_{glob}$$
 = actual irradiance
 F'_{glob} = measured irradiance

 $F_{glob} / F'_{glob} = (F_{diff} + F_{dir}) / (F'_{diff} + F'_{dir})$

After rearranging terms

Fdir / Fdiff is calculated using a radiative transfer model: LibRadTran/uvspec.

The model needs as input the following UV-affecting factors:

Total ozone: From Brewer measurements

Aerosols: Visibility is used (at FMI from AWS)

Albedo: Constant value

SZA: From Brewer spectral measurements

Cloud optical depth: from a lookup table

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Lookup table

Generated for each Brewer wavelength 286.5 nm – 365 nm.

LibRadTran / uvspec is used.

Global irradiance is calculated using the following possibilities: Total ozone ranging from 250 DU to 450 DU with steps of 50 DU Visibility ranging from 5 km to 60 km with steps of 15 km. Albedo ranging from 0.03 to 0.83 with steps of 0.2 Cloud optical depth ranging from 0 to 125 with steps of 5. SZA ranging from 0 to 90 with steps of 10 degrees.

A lookup table with dimensions 26 x 1250

Cloud optical depth can be retrieved using the Brewer irradiance multiplied by the "first guess" cosine correction factor, which is the factor (F'_{diff}/F_{diff}) assuming all sky radiation to be diffuse.

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3. Instruments

Data from five Brewers were used:

- Brewer #070 (AEMET)
- Brewer #117 (AEMET)
- Brewer #151 (AEMET)
- Brewer #166 (AEMET)
- Brewer #214 (FMI)

The slit functions differed a little bit from each other. \rightarrow Affected the final cosine correction factor less than 1%.

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Brewer #214/normalised relative response at 310 nm

Brewer #070/normalised relative response

Brewer #151/normalised relative response

Brewer #117/normalised relative response

The average of the four AZ has been calculated to get the cosine response

Assuming all radiation to be diffuse, the ratios between measured and actual diffuse irradiances are:

F´_{diff} / F_{diff} #070: 0.91 #117: 0.92 #151: 0.92 #166: 0.89 #214: 0.91

 $C = F(\theta)/F(0)$ angular response of the diffuser

4. Results

Diurnal variation of the cosine correction factor at 308 nm.

Spectral variation of the cosine correction factor.

Global irradiance ratios 070C/QASUME at El_Arenosillo-matshic:02-Jun-2015(153) to 04-Jun-2015(155)

Brewer #117 Compared to QASUME

Global irradiance ratios 166C/QASUME at El_Arenosillo-matshic:02-Jun-2015(153) to 02-Jun-2015(153)

Open questions:

- During the campaign, there was mostly clear sky
- \rightarrow what is the performance during changing cloud cover?
- Have angular responses of the Brewers changed since 2005?
- Is it OK to use the average of all AZ when calculating the angular response of the diffuser?
- How about the wavelength dependence of the angular response of the diffuser?
- What is the effect of the T-dependence?
- What are the effects of the input parameters of both the lookup table and the uvspec, when simulating the dir/diff ratio?

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References

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