Accurate and Simple Parametrization to Estimate Solar UV From GHI and Other Accessible Variables

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This study is part of a broader program that aims to generate reliable ultraviolet (UV) data for several applications. This work presents a simple and fast parametrization to estimate UV solar irradiation at the ground level from global horizontal irradiance (GHI) information. We focus on UVB (280 nm–315 nm) and erythemic UV (UVE) irradiance weighted by the average skin response.

Context:

- GHI can be a used as a proxy to estimate UV with good accuracy [1].
- Using quality GHI estimates from satellite models, such as the National Solar Radiation Database (NSRDB), accurate UV parametrizations from GHI allow obtaining accurate, long-term UV information with high temporal resolution and high spatial coverage.
- These quality UV data are usually scarce and are required for characterization, climatology, and other applications, such as for human health.

Previous Study

We studied the performance of several empirical parametrizations to estimate UV fractions (f_{UV}= UV/GHI) [1]:

- The best predictors are relative air mass (m), clearness index (kt), and ozone column ([O_3]).
- The models obtained outperform the models based on radiative transfer calculations [2].
- The best f_{UV} parametrization is based on a power function structure:

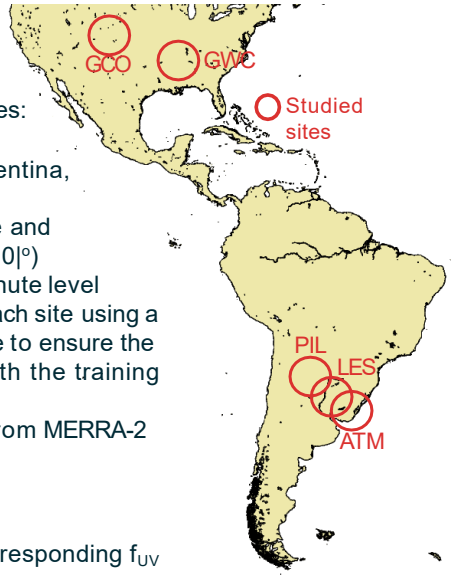
$$f_{UV} = a_0 k_t^{a_1} m^{a_2} [O_3]^{a_3}$$

Coefficients a_i are specific for each UV sub-band (UVB and UVE).

This Work

We train the f_{UV} parametrization using simultaneous high-quality UV and GHI measurements over 5 sites:

- 2 sites in the United States, 1 in Argentina, and 2 in Uruguay
- All with similar temperate climate and midlatitudes (between |30|° and |40|°)
- 4 years of data per site at a 15-minute level
- Coefficients were obtained for each site using a standard cross-validation technique to ensure the independence of the validation with the training data set.
- The ozone column was obtained from MERRA-2 reanalysis.

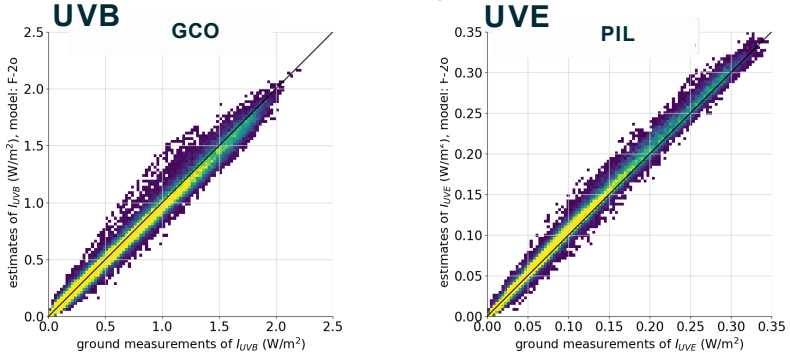


Performance of UVB and UVE Models

The models' performance is presented. The UVB and UVE estimates were generated using the corresponding f_{UV} parametrization along with ground GHI measurements. Each parametrization uses a unique set of coefficients for each band. The coefficient sets were obtained as averages of the site-specific parameters obtained over the 5 sites.

Results:

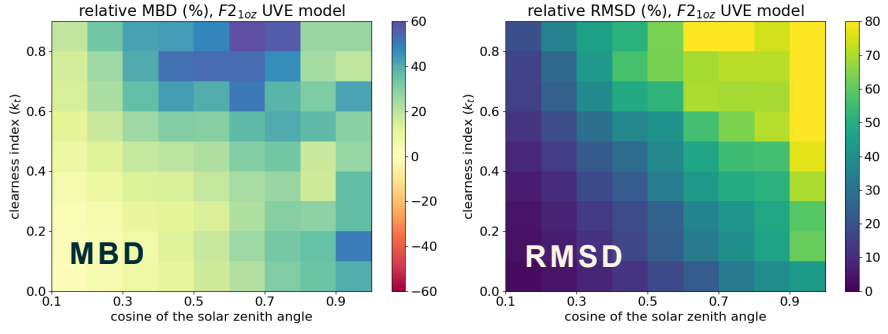
Scatterplots:



	UVB		UVE			
	GCO	ATM	GCO	GWN	LES	PIL
rMBD (%)	-2.3	9.3	-1.9	5.4	-3.0	3.5
rRMSD (%)	9.9	17.9	11.8	11.3	10.3	8.8
Correlation	0.995	0.990	0.993	0.995	0.996	0.997
Mean (W/m²)	0.52	0.51	0.070	0.068	0.089	0.084
data pairs	78735	19277	78901	77765	59026	58431

Relative metrics are expressed as a percentage of the measurements' mean.

Metrics discriminated by solar altitude and kt (UVE):



Conclusions

- 15-minute UVB and UVE can be estimated with high accuracy based on GHI information and an f_{UV} model: rMBD<|6%| and rRMSD <12% (except for ATM).
- For midlatitude temperate climates, the empirical coefficients are robust enough for estimating UVB and UVE with a set of averaged ("universal") coefficients.
- The f_{UV} model used with a satellite GHI model allows for generating UV series on demand with high spatiotemporal coverage.

[1] A. Laguarda and G. Abal. 2019. "Assessment of Empirical Models to Estimate UV-A, UV-B and UV-E Solar Irradiance fFom GHI." ISES SWC 2019 Conference Proceedings.

[2] C. Thomas et al. 2019. "Assessment of Six Different Methods for the Estimation of Surface Ultra-Violet Fluxes at One Location in Uruguay." ISES SWC 2019 Conference Proceedings.

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