COMPARISON OF MEASURED AND MODELLED UV SPECTRAL IRRADIANCE AT THE IZAÑA STATION BASED ON LIBRADTRAN AND UVA-GOA MODELS.

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This work compares spectral measurements made with the spectroradiometer *Bentham DMT300* and the simulations obtained with two radiative transfer models *UVA-GOA* and *LibRadtran*. The measurements were made on the 1st of June of 2005, during the *QASUME* (Quality Assurance of Solar Ultraviolet Spectral Irradiance Measurements) intercomparison at the Izaña station. This station belongs to AEMET(Meteorological State Agency of Spain), and is located on Tenerife Island (Spain) at 2.400 m above sea level (28º17.9´ N, 16º24.96´ W). This work was developed within the Specific Agreement of Collaboration between the University of Valladolid and the CIAI-AEMET "Establish methodologies and quality assurance systems for programs of photometry, radiometry, atmospheric ozone and aerosols within the atmospheric monitoring program of the WMO".

IZAÑA STATION

Izaña station (IZO) is located on the island of Tenerife at 28º17.9'N, 16º24.96'W, 2400 m.a.s.l. The observatory is located on the top of a mountain plateau in the pre-national park area (Teide National Park) that is environmentally protected by the "sky law". IZO is normally above a temperature inversion layer, generally well established over the island, and thus free of local anthropogenic influences.

INSTRUMENT AND QUASUME INTERCOMPARISON CAMPAIGN

Instrument: Spectroradiometer BENTHAM DMT300,

- Belonging to the University of Innsbruck, Austria.
- The Bentham DTM 300 consists of a double monochromator with a 300 mm focal length and two sets of holographic gratings with 1200 and 2400 lines mm, respectively. With the 2400 lines mm grating, the spectral resolution is 0.48 nm (FWHM) and the wavelength setting uncertainty is less than 0.1 nm. The usual operational wavelength range is between 280 and 500 nm (Kazadzis et al.,2005).
- Measurements of global and direct solar irradiance spectra from 290 to 500 nm in steps of 0.5 nm and with a spectral resolution of 0.8 nm (FWHM)

The QASUME ("Quality Assurance of Solar Ultraviolet Spectral Irradiance Measurements in Europe") intercomparison campaign took place at the high altitude site of Izaña, in Tenerife during June 2005.The objectives of the campaign were to improve the quality of direct solar irradiance spectral measurements, through instrumental modifications and standardization of calibration techniques, as well as to assess the significance of the differences in the field of view of the spectroradiometers with respect to aerosols and to solar zenith angle.

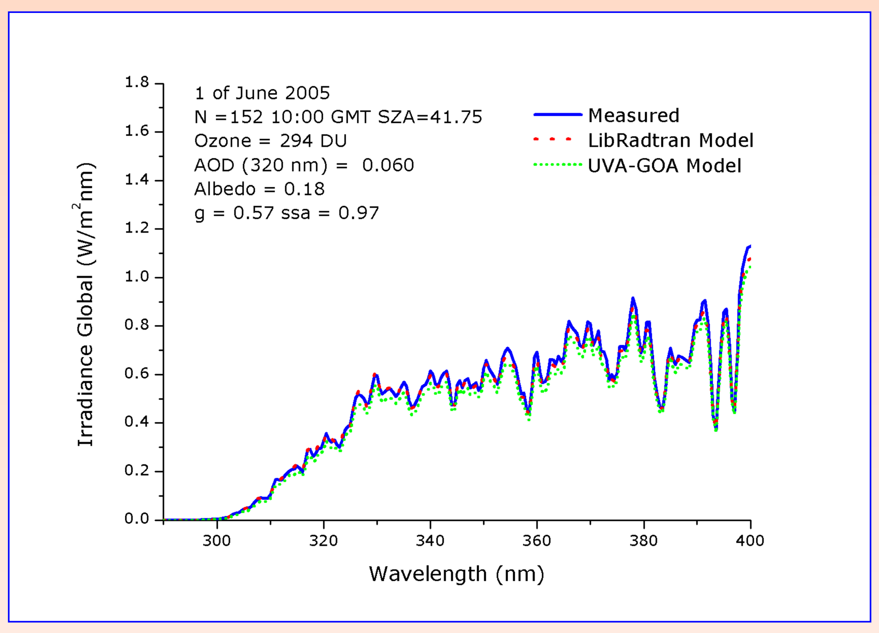
UVA-GOA MODEL

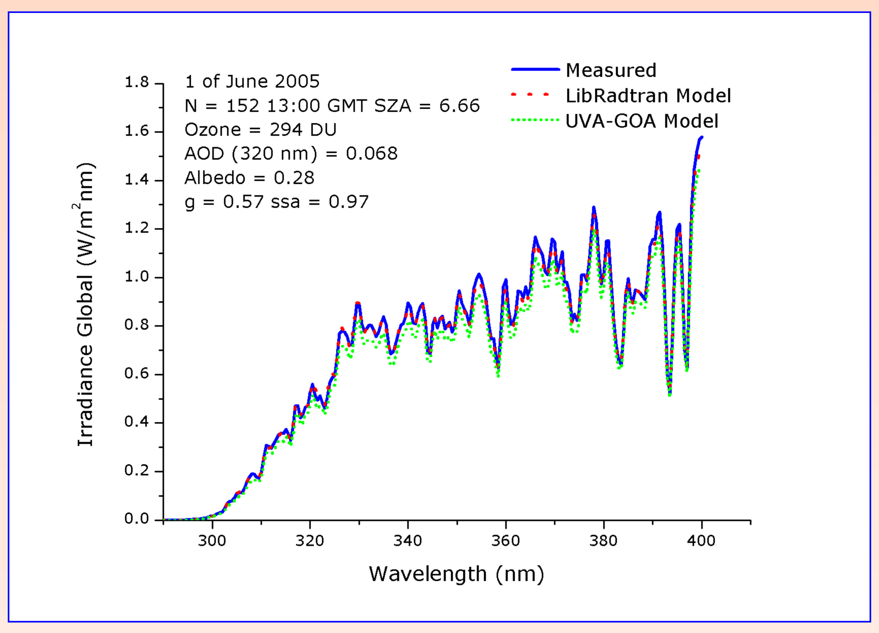
- Author: Dr. Victoria Cachorro. Atmospheric Optics Group, Valladolid University (GOA-UVA) (Cachorro et al.,2000) (Cachorro et al.,2002)
- Spectral and monolayer radiative transfer model.
- It was originally designed to calculate spectral irradiance of 280-1100 nm and it is adapted to the UV region of 280-400 nm.
- The method of solving the radiative transfer equation is based on a method of Ambartsumian (Sobolev, 1963), giving a parametric equation for the global transmittance of the mono-layer atmosphere (One-dimensional model).
- The direct normal irradiance is given by the Beer-Lambert-Bourger law. The transmittance of the atmosphere can be expressed as a multiplication of the transmittances due to each of these separate effects: Scattering by molecules (Rayleigh Optical Depth), scattering by aerosols (Aerosol Optical Depth) and selective absorption.

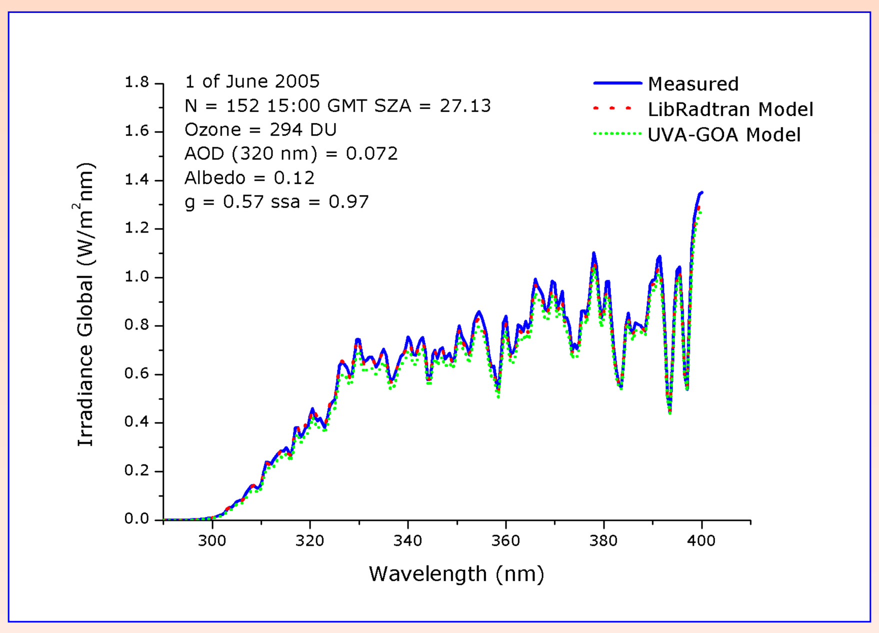
LIBRADTRAN MODEL

- Version: LibRadtran 1.4 (http://www.libradtran.org)
- Authors: Bernhard Mayer, Arve Kylling, Ulrich Hamann and Claudia Emde (Mayer and Kylling, 2005).
- A set of tools that allows calculations of radiative transfer in Earth's atmosphere.
- Transfer radiative model : UVSpec.
- Spectral radiative transfer model, multilayer and multiple scattering.
- It was originally designed to calculate spectral irradiance in the ultraviolet and visible spectral ranges and actuality also extend to thermal spectral range.
- One-dimensional model.
- The radiative transfer model allows to use seven different algorithms to solve the radiative transfer equation: Disort, Polradtran, Twostr, sdisort, spsdisort, …
- Both water and ice clouds models are included in UVSpec.
- More than 200 input parameters provided in the LibRadtran model.

COMPARISON UVA-GOA AND LIBRADTRAN MODELS







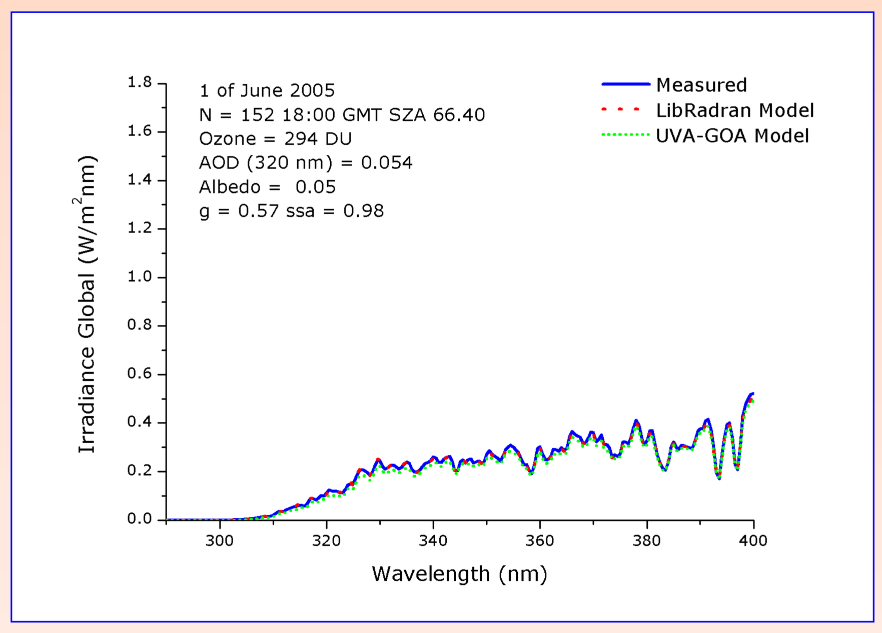


Figure 1.- Comparisons between the solar UV global irradiance spectra observed with spectroradiometer Bentham at Izaña in 1 June 2005, and simulated with the LibRadtran and UVA-GOA models at 4 different solar zenith angles.

Model Inputs:

Extraterrestrial spectrum: Kurucz wavelength range: 250-10000 nm (Kurucz,1992).
Cross Section Ozone: Bass and Paur (1985)

GMT	SZA(º)	Albedo	AOD (320 nm)
8:00	67.83º	0.35	0.053
9:00	54.88º	0.25	0.053
10:00	41.75º	0.18	0.060
11:00	28.59º	0.20	0.068
12:00	15.76º	0.20	0.062
13:00	6.66º	0.28	0.068
14:00	14.41º	0.25	0.087
15:00	27.13º	0.12	0.072
16:00	40.29º	0.05	0.068
17:00	53.43º	0.05	0.063
18:00	66.40º	0.05	0.054

Ozone 294 ± 1 DU
Assymmetry factor 0.57 ± 0.05
Single scattering albedo 0.97 ± 0.04

		UV-B [300-320 nm]								UV-A [320-340 nm]							
		Measured/LibRadtran				Measured/UVA-GOA				Measured/LibRadtran				Measured/UVA-GOA			
GMT	SZA(º)	Mean	Min	Max	Std.	Mean	Min	Max	Std	Mean	Min	Max	Std.	Mean	Min	Max	Std
10:00	41.75	0.420	-5.312	9.330	3.509	15.444	7.724	25.995	5.806	2.006	-5.180	2.004	5.653	7.175	3.279	11.501	1.283
13:00	6.66	-0.220	-4.653	5.736	2.646	10.898	6.590	16.522	3.071	1.011	-4.819	4.302	1.706	6.815	2.835	9.515	1.267
15:00	27.13	-0.468	-6.128	5.712	2.780	12.407	6.926	19.024	3.781	1.581	-3.964	4.617	1.624	5.943	1.566	9.887	1.426
18:00	66.40	-1.418	-10.834	12.972	5.675	34.551	14.838	67.777	16.178	2.062	-6.832	7.675	2.144	7.889	2.758	20.758	2.940

Table 1.- Relative Differences (Percentages) between the model calculations and the measurement for global irradiance

Measured/UVA-GOA Model:

In the spectral range between 300 nm and 320 nm the relative differences are 6% - 16% for a SZA of 6.66 º. As the SZA increases this difference increases reaching a maximum of 67% for a SZA of 66.40 ° and a wavelength of 300 nm. From 320 nm the relative differences remain almost constant below 10% except for a SZA of 66.40º. From 355 nm the difference is always less 10% for all the considered SZA. This results shows that UVA-GOA model has sufficient accurate to evaluate spectral and integral UV measurements in different sites and under different atmospheric conditions. This comparison with experimental measurements at high mountain stations (García, 2008) .

Measured/LibRadtran Model:

The trend of the comparison between the experimental and simulated LibRadtran model is very similar to the behavior of the comparison with the UVA-GOA model, except that there is not a clear trend of decline like in the comparison with UVA–GOA model. Between 300 and 320 nm the difference is between ± 12% and between 320 and 400 nm within ± 8%, from 340 nm the difference is between 2% and 4% (García,2008).

These differences are mainly related to three factors that differentiate the two models:

- The vertical profiles of the atmosphere introduced into the LibRadran model.
- The solution of the radiative transfer equation
- UVA-GOA model overestimates the selective absorption of ozone

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Acknowledgements: Financial supports from the Spanish MICIIN (ref. CGL2008-05939-CO3-00/CLI and CGL 2009-09740) and from the GR-220 Project of the Junta de Castilla y León are gratefully acknowledged. We authors wish to thank Dr. Mario Blumthaler to facilitate measured the Bentham Spectrorradiometer and we wish to acknowledge the AERONET-PHOTONS-RIMA networks (http://aeronet.gsfc.nasa.gov) and the LibRadtran model (http://www.libradtran.org).

37th Annual European Meeting on Atmospheric Studies by Optical Methods. Valladolid 23-26 August 2010