SUN PHOTOMETER MODEL SPUV

BULLETIN SPUV-6-10

General Description

The SPUV is a precision sun photometer that measures direct solar spectral irradiance at up to ten discrete wavelengths in the UV-B and visible regions. The SPUV exceeds the WMO specifications for sun photometers and is the first commercial sun photometer to measure narrow bandwidths in the UV-B. For applications such as column ozone or atmospheric turbidity measurements, which require the measurement of discrete spectral lines in the solar spectrum, the SPUV offers the capabilities and accuracy of a scanning spectroradiometer but at a fraction of the cost and with less maintenance overhead.

The SPUV is a rugged instrument designed for long-term operation in the field. It is environmentally sealed and desiccated. All temperature-sensitive elements are located in a thermally controlled enclosure, which provides freedom from the effects of changes in ambient temperature. Finally, each SPUV channel has its own calibrated detector; no moving filter wheel is necessary.

Channel Configuration Options

The SPUV is a versatile instrument that can be configured with six or ten channels at various wavelengths. Typical configurations include the WMO recommended wavelengths for atmospheric turbidity measurements (368, 500, 673, 778 and 870 nm) and ozone column measurements (300, 311.4 and 317.5 nm or 500, 615 and 673 nm). FWHM is 2 nm or 10 nm, depending on wavelength. The modular design of the SPUV allows individual channels to be added or removed while the instrument remains at the site.

Applications

Typical applications include

- Column ozone, water vapor, and NO_2 measurements
- Atmospheric turbidity measurements
- Solar UV spectrum analysis
- Aerosol and optical depth measurements

SPUV-10 mounted on an ST-1 tracker

Principle of Operation

The SPUV is normally used to measure the optical depth of an atmospheric constituent, for example ozone or aerosols. The principle of measurement is based on Beer's Law

$$S(\lambda) = S_o(\lambda) e^{-m \cdot \delta(\lambda)}$$

where S_o and S are the solar spectral irradiances outside the atmosphere and at the Earth's surface respectively, λ is the wavelength, m is the air mass (normalized to unity for solar zenith angle of 0^o) and $\delta(\lambda)$ is the total optical depth. The total optical depth can be written as a sum of optical depths of relevant atmospheric constituents.

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For example, when making measurements near 300 nm, $\delta(\lambda)$ can be written as

$$\delta(\lambda) = \delta_A(\lambda) + (p/p_o)\delta_R(\lambda) + \delta_{oz}(\lambda)$$

where δ_A, δ_{oz} and $(p/p_o)\delta_R$ are the aerosol, ozone and molecular (Rayleigh scattering) optical depths at an atmospheric pressure p (p_o = 1013.25 hPa). Column ozone amounts can be further obtained by:

- Measuring spectral irradiances at several wavelengths where the ozone absorption cross sections are both large and small
- Using Beer's Law and the ratio of the strong and weak absorption measurements to solve for the ozone optical depth
- Using the known ozone absorption cross sections, calculate the column ozone from the optical depth

Instrument Operation

The SPUV is mounted on a user-supplied solar tracker and is maintained pointed directly at the sun. The flat universal mounting plate on the SPUV enables it to be attached to most trackers. State-of-the-art thin film interference filters permit only photons within a prescribed wavelength to reach a dedicated detector. Filtered, monochromatic light is detected by solid state photodiodes and the resulting photocurrents are amplified by highly sensitive, ultra low noise electronic circuitry. Analog outputs, one for each wavelength are proportional to incident spectral irradiance and are fully characterized by the factory.

A YESDAS-2 data acquisition and control system digitizes each analog channel and YESDAS Manager software converts data into spectral irradiance calibrated in W/m^2-nm and provides automatic optical depth determinations via Langley analysis.

Note that unlike other sun photometers, each SPUV channel has a dedicated detector and amplifier - there is no mechanical "rotating filter wheel." All wavelengths are measured *simultaneously* which is a BSRN/WMO requirement. This design approach also makes the instrument highly reliable over its lifetime.

Instrument Design

The interference filters used in this instrument have exceptional long-term stability and out-of-band rejection properties. The filters and detectors are located in a thermally controlled enclosure and are held at a constant temperature so that they do not experience the thermal cycling due to day-night temperature variation. In addition, the design incorporates solar energy absorbing pre-filters on UV channels to minimize the amount of out-of-band energy that those filters are exposed to during operation.

Specifications

Wavelengths	Standard configuration includes choice of any six or ten of the following wavelengths: 300, 305.5, 311.4, 317.5, 325.5, 332.5, 368, 500, 615, 673, 778, 870, or 940 nm (UV filters: 2 nm FWHM bandpass; visible filters: 10 nm FWHM**)**
Field of view	Opening angle of 2.5° as prescribed by WMO #7
Temperature range	±50°C
Signal output	Analog outputs 0-4 VDC low impedance, single-ended, interfaces to YESDAS datalogger
Size	Spectrometer is 28.5 cm (11") long and 17.5 cm (6") in diameter; weight is 5 kg (11 lb.). Mounts on most standard trackers
Power input	+11 to 14 VDC, @2A — startup; drops to 1A typical
Weight	11 lb. (5 kg)
Tracker	The base plate of the SPUV adapts to most solar trackers

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