European Journal of Applied Sciences – Vol. 11, No. 2
Publication Date: April 25, 2023
DOI:10.14738/aivp.112.14429.
Hoisington, R. D., Whiteside, M., & Herndon, J. M. (2023). Unequivocal Detection of Solar Ultraviolet Radiation 250-300 nm (UV-C) at Earth's Surface. European Journal of Applied Sciences, Vol - 11(2). 455-472.

SERVICES FOR SCIENCE AND EDUCATION

Unequivocal Detection of Solar Ultraviolet Radiation 250-300 nm (UV-C) at Earth's Surface

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ABSTRACT

The toxicity of ultraviolet radiation in wavelength range 100-280 nm (UV-C) is well documented. UV-C irradiation can cause skin cancer, premature aging, visual problems and blindness. Prolonged exposure to UV radiation can kill both plants and animals, including entire forests. There are numerous assertions in the medical, public health, and geoscience literature that no UV-C reaches Earth's surface, despite several studies to the contrary including one in 2007 by NASA. Naysayers blame technical problems such as stray light. Low-level UV-C measurements are difficult, if not nearly impossible, when using low integration values in the CCD Imaging Spectral Radiometers. This is due to the instrument's internal and external atmospheric stray light issues, issues which even occur during calibration procedures that employ heated filament or gas-filled lamps. To obviate these inherent problems, one of us (RDH) designed, engineered, and constructed a Double Monochromator utilized in conjunction with the ILT950UV Spectral Radiometer operating in the raw data mode. Each of the initial measurements of solar irradiance displayed evidence of UV-C arriving at Earth's surface, not high in the mountains, but just 176 meters above sea-level. These data were taken in the raw data mode, corrected for prism loss, with instrument noise, i.e. machine errors, subtracted. The non-zero value for relative spectral irradiance clearly shows the existence of UV-C at Earth's surface, in the range 250-300 nm, even when measured under less than optimum atmospheric conditions. Research and development continue. We must know with certainty the condition of the stratospheric ozone layer that shields surface life from solar UV-C. Covert geoengineering atmospheric particulate pollution, in combination with industrial pollution of the atmosphere, is killing Earth's stratospheric ozone layer. If unabated, it will sound the death knell for much of life on Earth.

INTRODUCTION

Due to stratospheric ozone depletion, increasingly measurable amounts of harmful solar radiation are reaching Earth's surface. Extreme ultraviolet radiation (UV) in the form of UV-B and UV-C leads to serious and irreparable harm. It causes mutations in cellular DNA, which lead to major alterations in cell function and carcinogenesis. Other damaging effects of this type of radiation include premature aging, visual problems and blindness, and effects on fertility.

Prolonged exposure to UV radiation can kill both plants and animals, and otherwise make them more susceptible to disease. Besides their direct biological effects, UV radiation has complex effects on biogeochemical processes [1].

The toxicity of ultraviolet radiation in wavelength range 100-280 nm (UV-C) is well documented. UV-C irradiation has lethal effects on insects and microorganisms [2, 3]. UV-C radiation induces programmed cell death, or apoptosis, in plant cells [4]. In a controlled study, numerous ultrastructural changes and associated cell damage were shown in mole rat kidney tissue cells irradiated with artificially produced UV-C radiation [5]. Medical students accidentally exposed for 90 minutes to UV-C radiation from a germicidal lamp all suffered reversible photokeratitis, and skin damage to the face, scalp, and neck [6].

For such a dangerous potentiality from solar radiation, it is remarkable that there are numerous assertions in the medical, public health, and geoscience literature that no UV-C reaches Earth's surface [7-13]. Those assertions are even more remarkable considering published evidence that solar UV-C does in fact reach Earth's surface [14-17].

In 2007, D'Antoni et al. [16] published spectral irradiance measurements made on two mountain slopes in Tierra del Fuego, Argentina with elevations ranging 245-655 m. All of their published results detected significant radiation in the UV-C region. There was criticism of the article [18] that was later adequately addressed by D'Antoni et al. [19]. Interest in this important topic disappeared over the next decade. As this was a NASA investigation, it should have been imperative that NASA take the lead in obtaining the most accurate and precise data related to solar UV-C reaching Earth's surface, but that never happened.

We have borne witness to how the natural world is suffering. The richness and diversity of life on Earth is disappearing at an incredible rate, and there are massive population declines of both animal and plant life [20-22]. Entire forests are slowly dying and one of the main culprits may well be increasing UV-B and UV-C [23, 24].

In 2018, we published solar spectrometric measurements that as well demonstrated that UV-C is reaching Earth's surface [17], reproduced here as Figure 1.

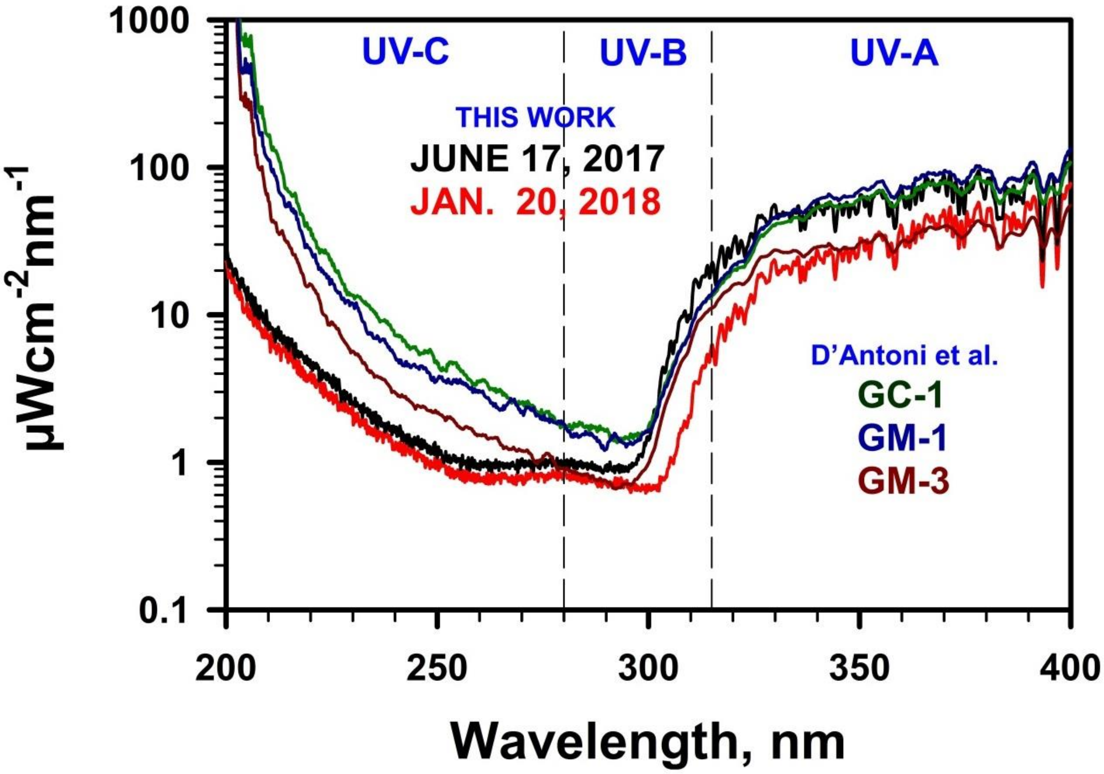

Figure 1. Comparison of our solar spectrometric measurements [17] with those of D'Antoni et al. [16].

There is remarkable similarity of our data [17] and those of D'Antoni et al. [16], despite the fact the measurements were taken using spectrometers by different manufacturers. There are commonalities, however. Both spectrometers utilized a charge-coupled device (CCD) sensor, and neither manufacturer would provide complete numerical calibration data.

When science is agenda-driven, as it is now and has been for the last several decades, scientific objectivity suffers. All too often contradictory measurements, like those of D'Antoni et al. [16], are simply ignored. Sometimes disinformation agents try to instill doubt by making pejorative assertions evoking potential spectrometer issues such as those arising from stray light.

Interestingly, in 1997 Córdoba et al. [14, 15] detected solar UV-C radiation at Earth's surface using a fundamentally different methodology, employing a KCl: Eu^{2+} dosimeter, which is not subject to stray light problems.

We have embarked on a quest to detect solar UV-C irradiance at Earth's surface in a manner and with a methodology that eliminates any potential technical error inherent in commercial spectrometers.

Here we report results of the first step of the investigation, providing unequivocal evidence of UV-C solar irradiance at Earth's surface in the range 250-300 nm expressed in relative units.

BACKGROUND, RATIONALE, AND CONSTRUCTION

Measurements, specifically, the low-level UV-C measurements, are difficult, and nearly impossible, when using low integration values in the CCD Imaging Spectral Radiometers. This is due to instrument internal, and external atmospheric stray light issues, issues which even occur during calibration procedures that employ heated filament or gas-filled lamps [25]. To obviate these inherent problems, one of us (RDH) designed and constructed a Double Monochromator utilized in conjunction with the ILT950UV Spectral Radiometer operating in the raw data mode. The subsequent reduction of stray light by the addition of the Double Monochromator allows greater sensitivity, selectivity and lower noise floor for more accurate solar UV irradiance measurements.

As this is the first report on the continuing research and development, we chose to focus on the bandwidth 250-300 nm and to conduct solar ultraviolet irradiance measurements using raw data from the ILT950UV, which is not subject to internally induced software calibration errors, that is Dark Reference corrected in external software after the data is gathered. This 'Dark Reference' is acquired by simply putting a cover over the light input to the Double Monochromator at mid-point of a data session, and completed at the end of that session. This data is then averaged, and subtracted from the raw data to remove the residual noise of the ILT950UV. This procedure eliminates stray light errors created during radiometer calibration. Several alternate methods of measuring solar radiation at Earth's surface were considered. The most important issues were found to be the internal baseline noise, and the internal stray light values generated by the various spectral radiometers. The most accurate instrument found to measure this solar radiation is called a Double Monochromator, with usually a photo multiplier tube or solid-state avalanche photo diode, often called photon counters. These instruments have extremely low levels of stray light issues. Using the Double Monochromator in conjunction with the ILT950UV will lower the "noise baseline" from the 0.3% (and the +/- 20% statement of the ILT950UV specifications) to baseline values that should allow for solar measurement values in the nanowatt region instead of the microwatt region – an increase in sensitivity of 1,000 times.

Monochromator means one wavelength of light, or "mono" - single, "chromator" – display of the color (wavelength) and can be fixed or adjustable. This single wavelength of light reduces the external stray issues most spectral radiometers exhibit by the first prism only allowing light transmission of a set wavelength(s) to pass, the second prism then doubles this reduction giving a total of 1,000 times more sensitivity – with baseline noise values as low as 0.002 microwatts, or 2.0 nanowatts.

The chosen Double Monochromator design involve using two prisms rather than using chromatic dispersion 'gratings' that also separate the various wavelengths and which would require higher gain in the sensor and spectral radiometer.

It was deemed important to incorporate prisms that had high transmission bandwidths extending above and below the desired wavelengths important to the current research. Dow Corning 7980 Fused Silica material was selected for high optical transmission and bandwidth characteristics, and while the very expensive versions of this material is not utilized here, the basic properties of the Standard Grade, with the reflection coefficients at multiple wavelengths were considered sufficient to complete this Double Monochromator, which is an experimental prototype project.

Two equilateral prisms with 15 X 15mm sides were selected for use in the Double Monochromator. The equilateral prism, of all the various shapes available, gives a more 'even', and linear chromatic dispersion presentation. Two important reasons – first, the second prism will give more dispersion within the bandwidth of study, and second, will provide for a lower level of stray light issues within the instrument by additional baffles. Both prisms would be adjustable in rotation, within the same 'plane'. In other words, both prisms would be mounted on pedestals capable of rotation in thousandths of degree increments. The overall engineering feat is to locate each prism center axis and height in free space in relation to each other as accurately as possible, and to maintain this accuracy during prism rotation.

Figures 2-7 provide a visual overview of the construction of the Double Monochromator.

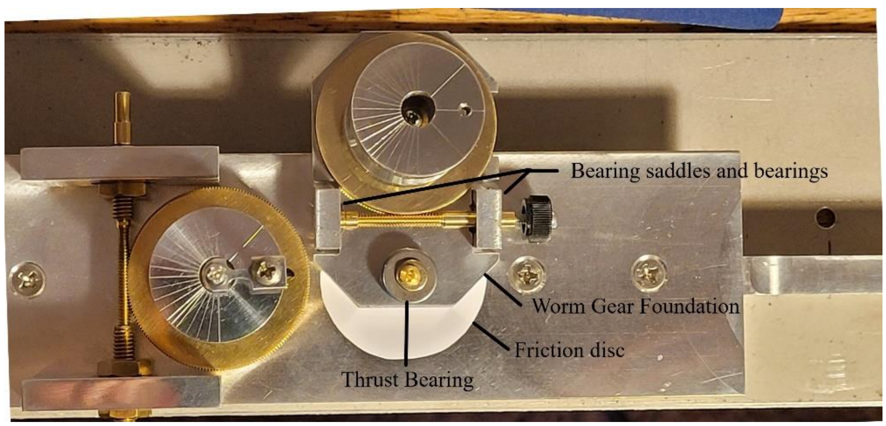

Figure 2. Prism #2 assembly installed on platform base. Pedestal tensioner screws can be seen through the upper hole of both prism pedestals. Prism #2 mounting plate thrust bearing is also visible.

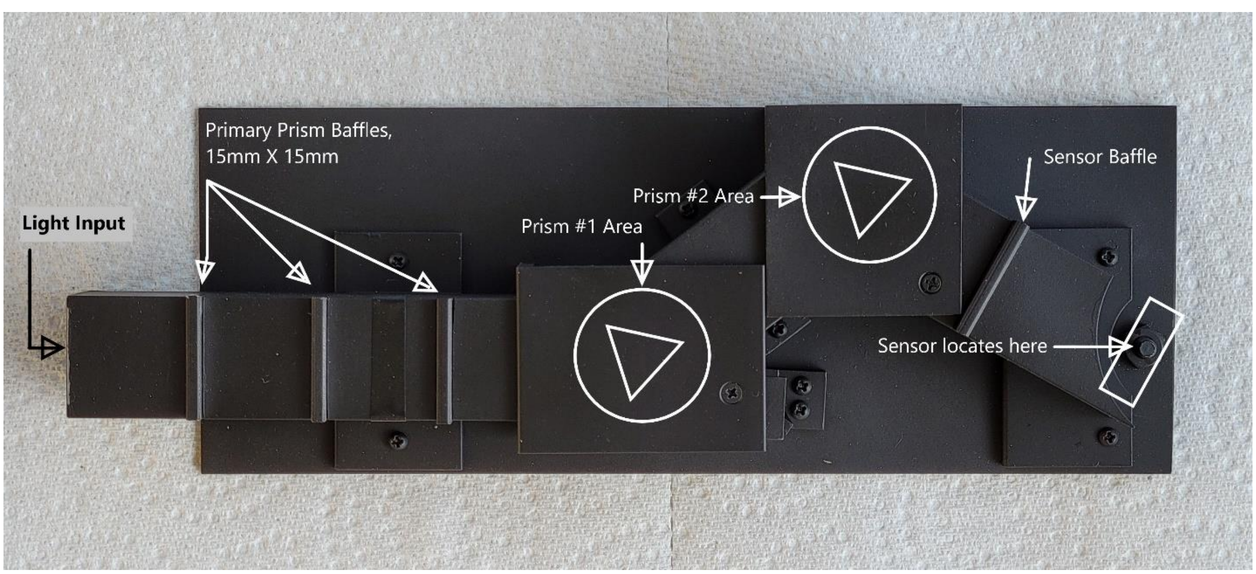

Figure 3. Optical baffle assembly.

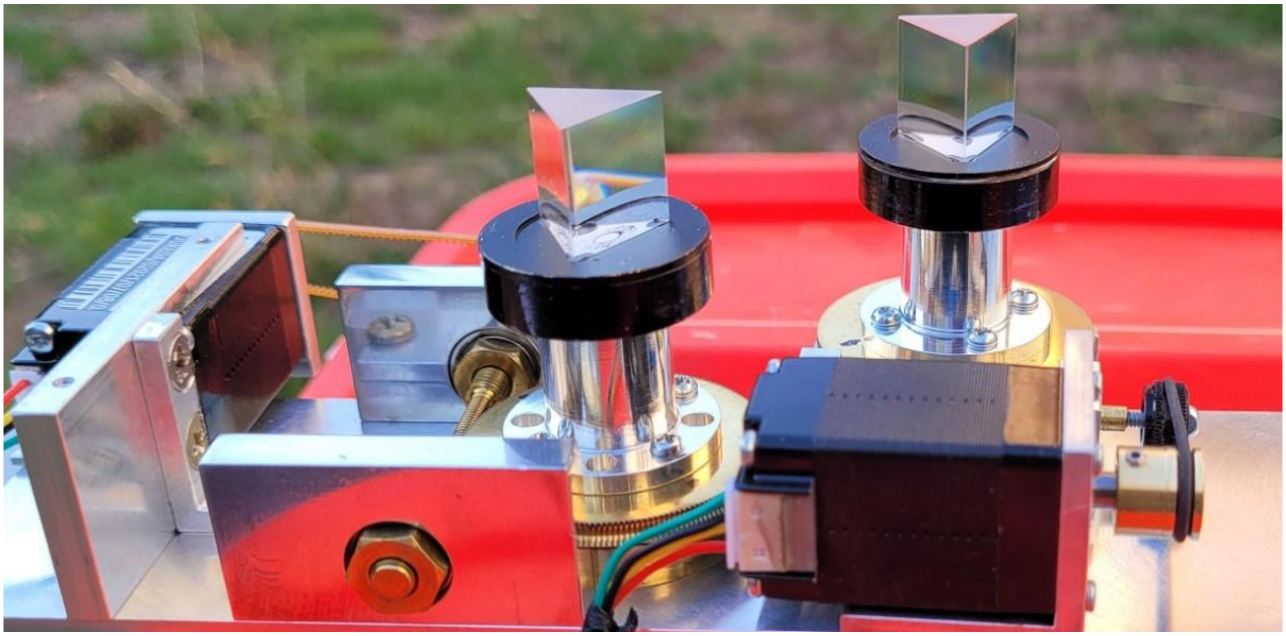

Figure 4. Mounted prisms and servo motors.

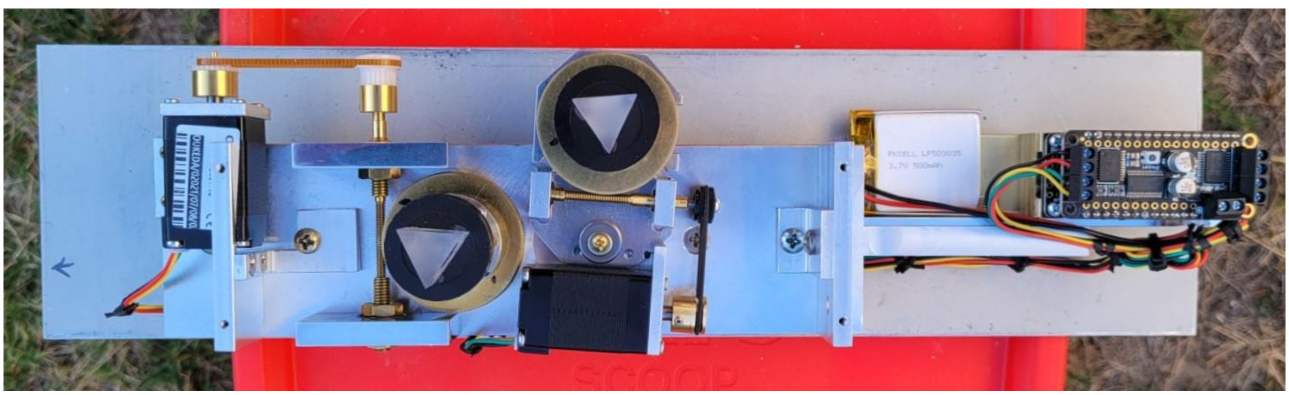

Figure 5. Stepper motors and computers mounted on platform base. Note the offset of Prism #2.

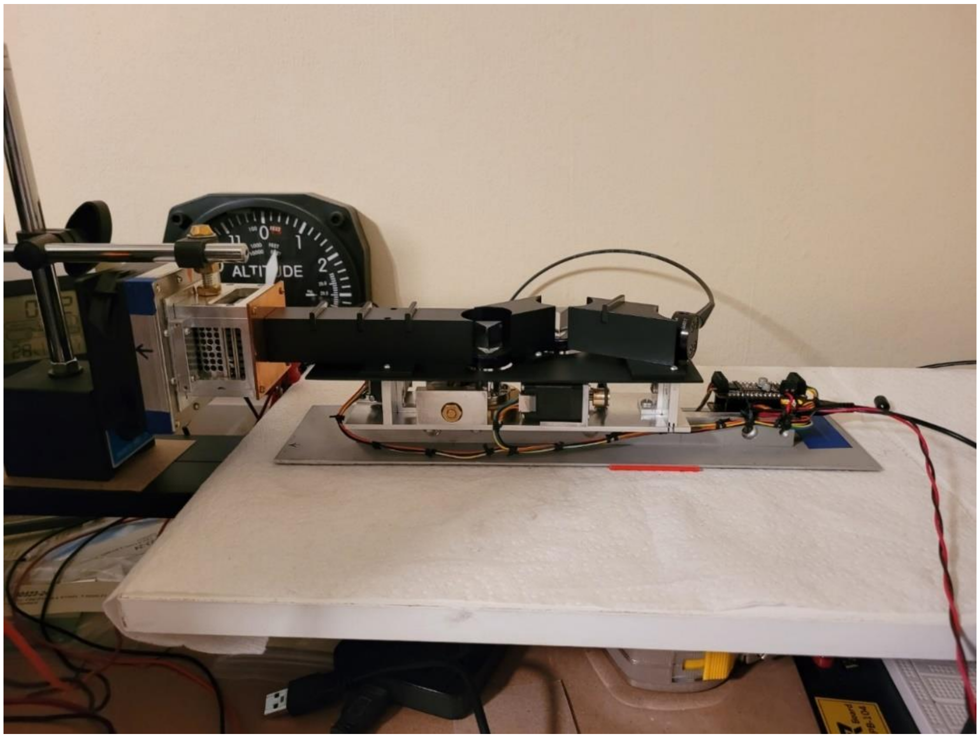

Figure 6. Double Monochromator and UV-C Reference Source on optical bench for evaluation. Prism covers are removed to observe prism rotation and position during testing. Note the RAA4 Sensor (with fiber optic line attached) after the second prism, and the computer assembly at the rear to drive the stepper motors.

Figure 7. Double Monochromator assembly affixed to the upper mounting rail on the telescope ring mount. The ILT950UV is within the ring mount.

UNEQUIVOCAL DETECTION OF UV-C AT EARTH'S SURFACE

For making initial measurements of the solar ultraviolet radiance in the 250-300 nm portion of the spectrum, it would have been desirable to have clear blue skies. But that was not to be the case. In addition to natural variations in cloud cover, a more persistent obscuration occurs on a near daily basis resulting from covert geoengineering activities [26, 27]. There are now two major classes of deliberately jet-sprayed pollution, shown in Figure 8, that occur on a near-daily basis.

Figure 8. Left: Coal fly ash chemtrails. Right: Organic substance jet-emplacement, less conspicuous, but potentially more devastating. Inset is a magnified view of the spray plane, indicated by the red arrow. From [28].

Nevertheless, each of initial measurements of solar irradiance displayed evidence of UV-C arriving an Earth's surface, not high in the mountains, but just 176 meters above sea-level, as shown in Figure 9. These data were taken in the raw data mode, corrected for prism loss, with instrument noise, i.e., machine errors, subtracted.

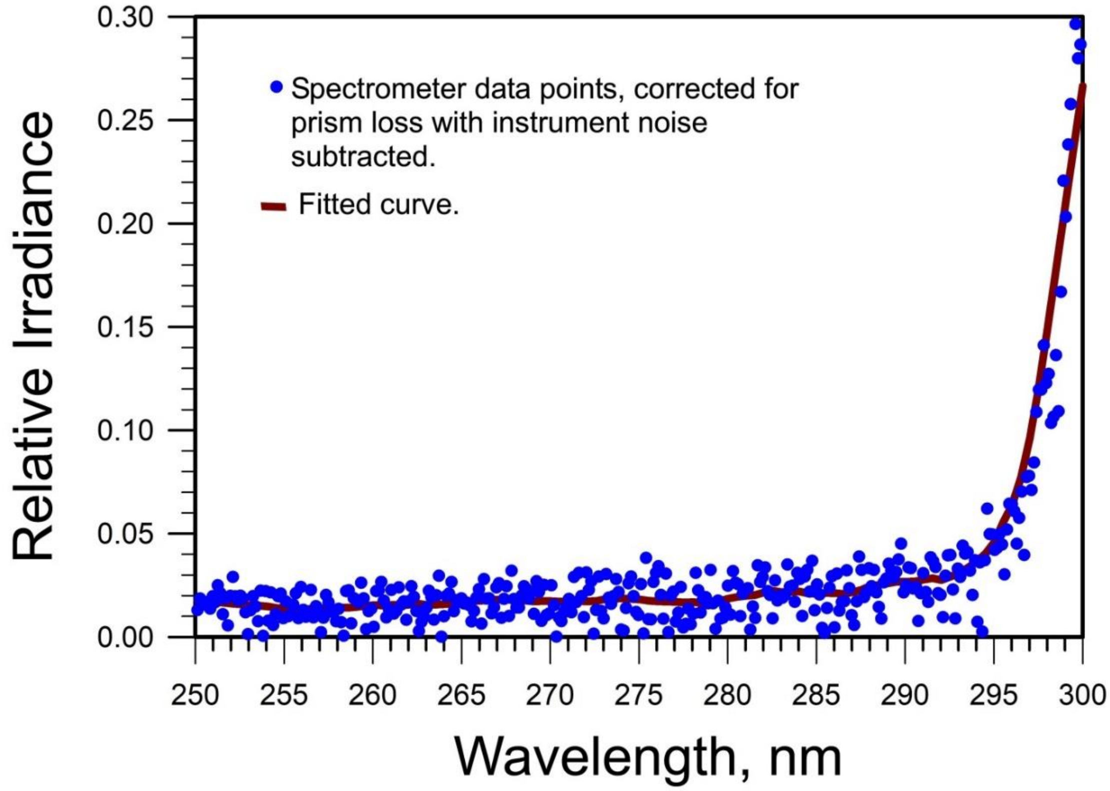

Figure 9. Solar spectral relative irradiance measurement in the range 250-300 nm.

Figure 10 shows the instrument noise, i.e., machine errors, data that was subtracted. Note that those errors are independent of wavelength for the entire range shown. These data were taken with the optical input blocked.

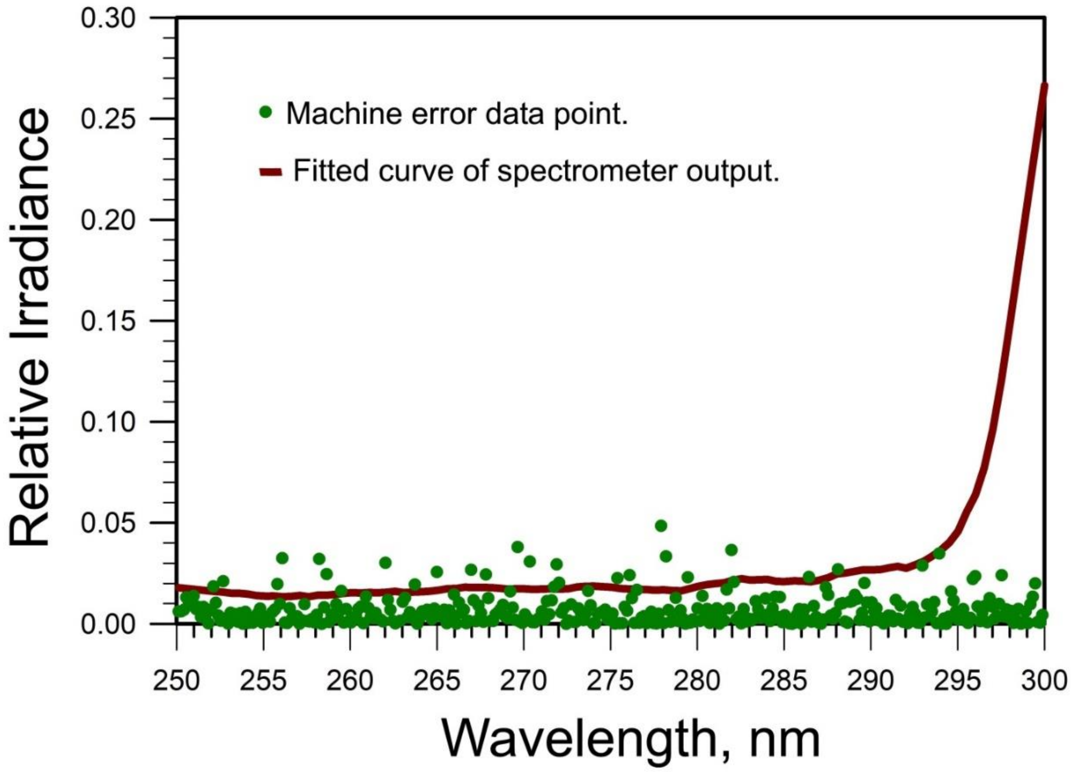

Figure 10. Measurement of instrument noise, i.e., machine errors, obtained by blocking the optical input.

The non-zero value for spectral relative irradiance clearly shows the existence of UV-C at Earth's surface, even when measured in less than optimum atmospheric conditions.

IMPLICATIONS OF ULTRAVIOLET IRRADIANCE AT EARTH'S SURFACE

Ultraviolet radiation UV-B (281-320 nm) and, especially, UV-C (100-280 nm) represent the most harmful and genotoxic components of the solar radiation spectrum. The maximum mutagenicity and lethal action of ultraviolet radiation fall into these wavelength categories. DNA is the key target for UV-induced damage in organisms ranging from bacteria to humans. The most common mutagenic and cytotoxic DNA lesions induced by UV radiation are cyclobutene-pyrimidine dimers (CPDs) and 6-4 photoproducts [29]. CPDs are the principal lesion for most DNA-damage-dependent biological effects of UV radiation in sunlight [30]. UV-C and to a lesser extent UV-B photons are directly absorbed by DNA bases, generating their excited states at the origin of the formation of the pyrimidine dimers. Ultraviolet light interacts with endogenous or exogenous photosensitizers and damages DNA by photosensitization reactions [31]. Most organisms including mammals have evolved DNA repair mechanisms, including photoactivation by the enzyme photolyase and nucleotide excision repair. However, prolonged exposure to damaging wavelengths can overcome these defense mechanisms [32].

Some of the most hazardous UV radiation has wavelengths in the UV-C range between 240 and 300 nanometers. Nucleic acids like DNA have a peak absorbance of UV around 260 nm [33]. Proteins have an absorbance maximum at about 280 nm due to the absorption by the aromatic amino acids in phenylalanine, tyrosine and tryptophan [34]. The incidence of toxicity from UV radiation depends on both wavelength and exposure time. The effects of UV wavelength on cell damage from UV radiation in PC12 (rat tumor) cells showed increasing toxicity in the following order: 250 nm>270nm>290nm>310 nm. There was better DNA repair at the longer wavelengths [35]. So-called "far UV-C" radiation (200-235 nm) is unable to penetrate to key living cells in the human epidermis. In a 3D human skin model, no increase in DNA damage was observed in skin cells (keratinocytes) at wavelengths from 215 to 235 nm, whereas significant DNA damage was observed at wavelengths from 240-255 nm [36]. Germicidal lamps that emit primarily 254 nm UV radiation are routinely used for surface sterilization but cannot be used for human skin because of their genotoxicity [37]. The UV-C wavelength with the greatest biological hazard is 270 nm [38] (Figure 11).

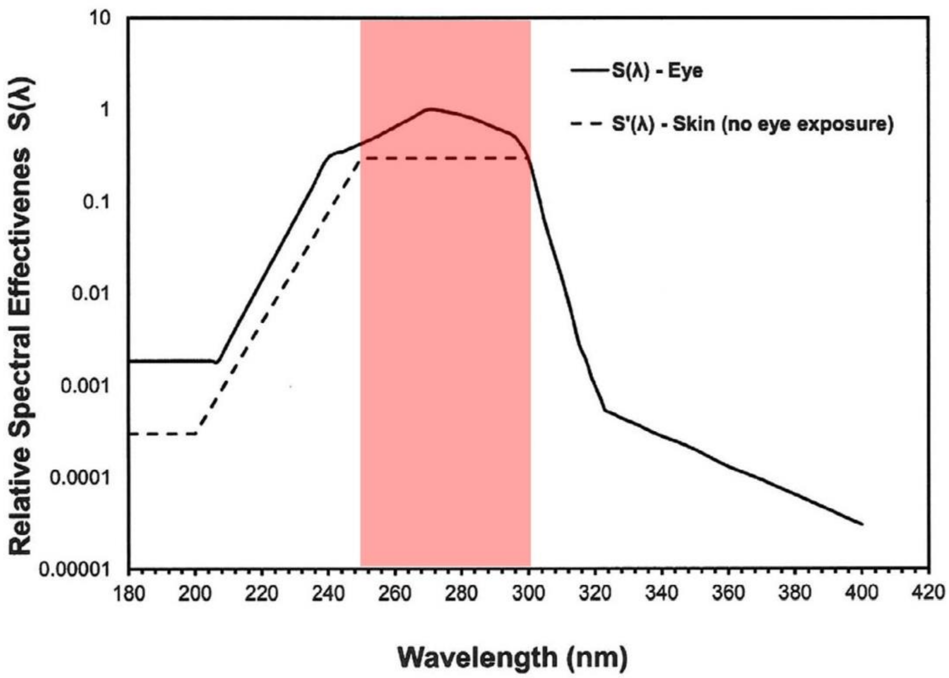

Figure 11 from [38] with added red band showing range of wavelengths reported here.

UV-C radiation from germicidal lamps poses human health risks. The American Conference of Governmental Industrial Hygienists and the International Commission on Non-Ionizing Radiation currently provide exposure guidelines [38]. Figure 11 represents the most recent UV proposed hazard functions, which differ somewhat for skin and eyes. The spectral effectiveness to cause damage to skin is related to wavelength, and is most damaging at 270 nm. From Figure 11, the harmful effects of 270 nm radiation are 9,000 times greater than those of 365 nm radiation.

As noted above, UV-C is toxic to virtually all life. UV-C irradiation has lethal effects on insects and microorganisms [2, 3] and induces programmed cell death, or apoptosis, in plant cells [4].

FATE OF UV-C IN EARTH'S GEOENGINEERED ATMOSPHERE

The authors (JMH and MW) have published compelling evidence that aerosolize coal fly ash particles are the main agents responsible for stratospheric ozone depletion [39-41] (Figure 12), not chlorofluorocarbon gases as asserted by the Montreal Protocol. Aerosolized coal fly ash particles, uplifted to the stratosphere, not only serve as ice-nucleating particles, but are trapped and concentrated in polar stratospheric clouds. In Springtime, as these polar clouds begin to melt and evaporate, the trapped ozone-consuming coal fly ash particles are released making them available to react with and consume stratospheric ozone which shields surface life from harmful solar ultraviolet radiation.

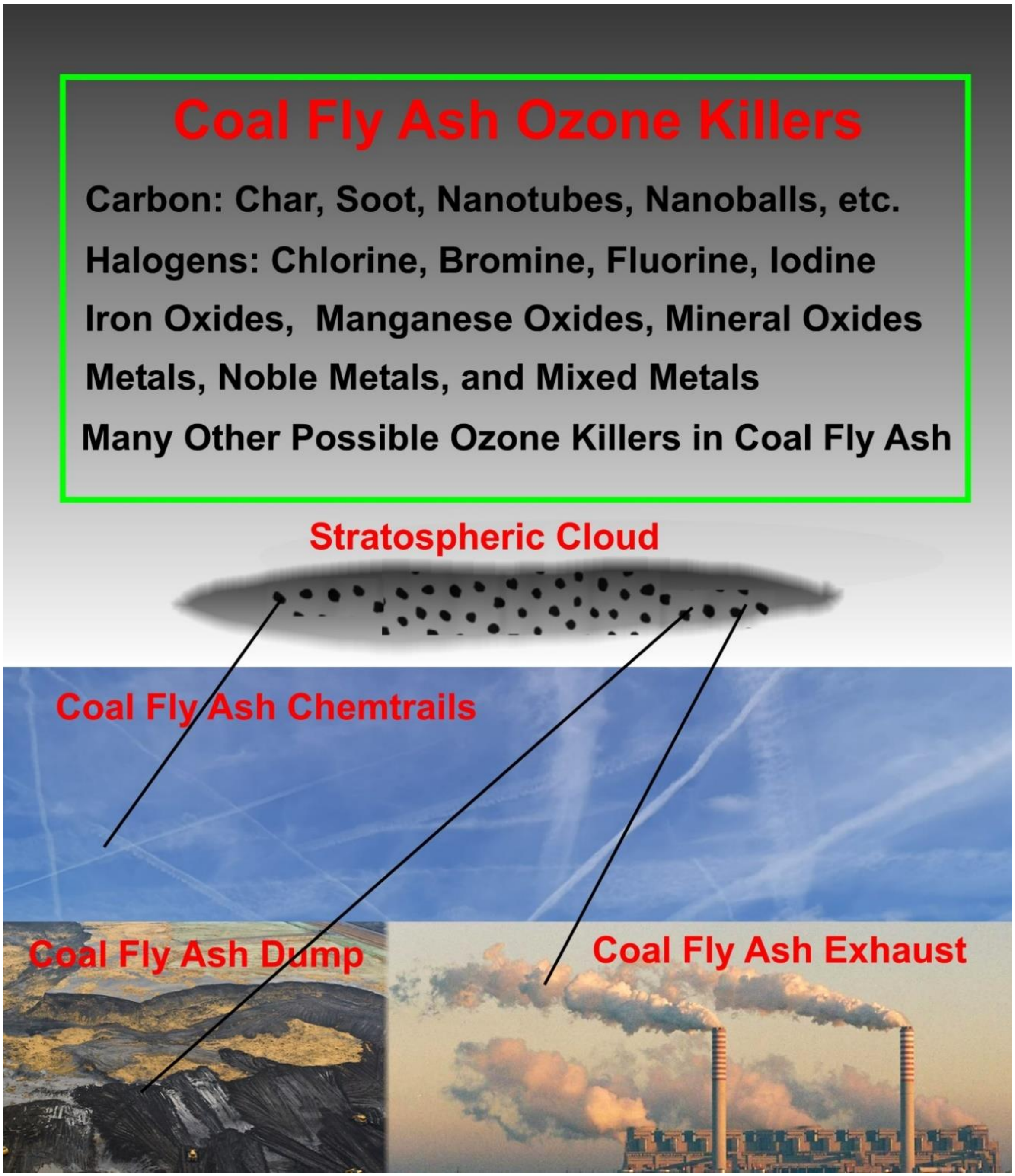

Figure 12. Graphic illustrating the major sources of aerosolized coal fly ash lofted into a particle laden polar stratospheric cloud, and some of the many components of coal fly ash that directly kill ozone [39, 42].

There is accumulating evidence that HULIS aerosols, including lignin, which are often mixed with coal fly ash aerosols, also play a key role in stratospheric ozone depletion [43]. These aerosols thus lead to an increased flux of UV-C, but paradoxically also absorb UV-C radiation (Figure 13).

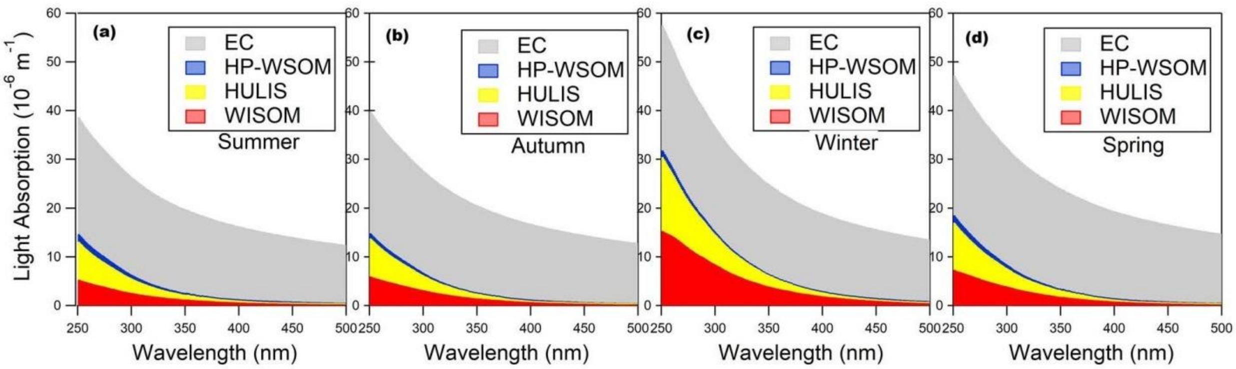

Figure 13. Stacked plots, abstracted from [44], of the seasonal averages of the contributions of the atmospheric organic aerosol (OA) fractions, and elemental carbon (EC), also called black carbon, to the total light absorption.

Enhanced solar ultraviolet radiation damages trees and weakens their resistance to pathogens [45-47]. Trees from many areas around the world, and indeed whole forests, are showing destructive changes in the trunk/branches and foliage which are especially prominent on sun-exposed surfaces. Figure 14, which is characteristic of numerous observations, shows examples predominate damage on the sun-exposed side of trees.

Figure 14. From left to right: A) Torrey Pine, *Pinus torreyana*; B) Gumbo-Limbo, *Bursera simaruba*, a full-sun, drought-tolerant tree in Key West, Florida (USA); C, D close up of sun damaged Gumbo-Limbo.

Short wavelength ultraviolet radiation is a major abiotic stressor to trees world-wide. Independent measurements document solar radiation in the range ≤ 300 nm now penetrating to Earth's surface, contrary to assertions [14, 16, 17, 48]. Ultraviolet radiation affects trees by modifying their biological and biochemical environment. The damage includes disruption of membranes and other cellular structures, generation of free radicals, inhibition of physiological processes, e.g., photosynthesis, nutrient assimilation, and chlorophyll and protein synthesis, all resulting in reduced growth and development of the tree [49]. Enhanced UV-B reduces genome stability in plants [50]. A recent study shows that high UV-B intensity leads to defective pollen development in conifers associated with decreased reproduction or even sterility [51].

CONCLUSIONS

Life on Earth exists due to the complex interrelationships by and between biota and planetary scale geophysical processes. For nearly the entire period of Earth's existence, life has flourished in this natural environment. Covert geoengineering atmospheric particulate pollution, in combination with industrial pollution of the atmosphere, is killing stratospheric ozone. If unabated, it will sound the death knell for much of life on Earth.

At the present time, Earth's global environment is threatened, not only by coal burning and geoengineering exacerbated global forest fires [52], but first and foremost by the undisclosed jet-spraying of coal fly ash and other particulates into the atmosphere. Evidence indicates the main motive is to melt polar ice, presumably to get at underlying natural resources [53].

Wholesale altering of Earth's natural environment by deliberately polluting the troposphere with particulate matter, especially coal fly ash and the new lignin-like substance shown in the right image of Figure 8, is destroying life on Earth [27]. Undisclosed tropospheric aerosol geoengineering will lead to unimaginably large increases in global warming [54-56] and in the demise of stratospheric ozone [39-41, 43], with associated increases in deadly ultraviolet UV-B and UV-C [53].

Despite evidence that the most harmful solar radiation, UV-C, reaches Earth's surface [14-17], nevertheless, assertions continue in the medical, public health, and geoscience literature claiming that no UV-C reaches Earth's surface [7-13]. Naysayers blame technical problems such as stray light [18].

Our desire to obtain unequivocal evidence of UV-C penetration to Earth's surface prompted one of us (RDH) to design, engineer, and construct a Double Monochromator to the ILT950UV spectrometer. Beginning as a prototype, this instrument has proven its value in near total reduction of stray light to unequivocally detect solar UV radiation in the 250 to 300 nm range. Research and development continue; we must know with certainty the condition of the stratospheric ozone layer, and the extent of damage being caused by UV-B and UV-C.

The solution to these major environmental problems is simple and quick acting: Cease geoengineering operations and reduce or eliminate sources of coal and biomass emissions, both primary sources of atmospheric HULIS [43]. The good news is that reducing atmospheric particulates will reduce global warming in a matter of weeks or months and allow Earth's vital life support systems like the stratospheric ozone layer to begin to recover. Moreover, a much healthier, natural environment will be the reward.

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