Title: Project SUN (Students Understanding Nature)

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BACKGROUND

Project SUN was initiated via a small grant from NASA's Mission to Planet Earth. It was designed to be an educational program that was driven by scientific requirements. The basic science aim is to produce long term, scientifically valid, time resolved, survey data of Earth surface solar radiation in both the visible and erythemal UV (see below) ranges. At the same time, this data is correlated with detailed local weather information. The student teams aim to produce data good enough to allow eventual peer reviewed publication.

Educationally, Project SUN's goal was to allow students to learn science via on-the-job training; that is learn science by doing real science. In addition to the survey effort, students are encouraged to use the data collected for their own research interests. Project SUN also sought to elevate the appreciation of scientific research in the minds of teachers and students.

APPROACH TO SCHOOLS

Interested teachers and their classes are given a brief presentation on the need for the long term study of both the visible and ultraviolet solar surface radiation. If they wish to join the project, it is suggested that it be done via a "research team" that will be long term, just as the athletic teams are. However, above all, the scientific data they will produce must be of "professional" quality or the project will be a failure.

If they request to become part of Project SUN, they are given further hands-on training, a SUN kit (visible light pyranometer, special filter UV sensor, interfaces, software, test instruments and handbook). The school must supply old computers that can be used as dedicated data loggers (Apple, Macintosh, soon PC). The school is then allowed all the time they feel they may need to develop their skills, with periodic support calls to the teacher.

DEVELOPMENT OF A RESEARCH TEAM

The key to success for the school and Project SUN is the teacher. If the teacher is "hands-on" i.e., an amateur radio operator, amateur astronomer, computer buff, etc.,then he or she will be able to solve the problems that always arise in research (broken wires etc.) and the team will succeed. The time it takes for school teams to be able to start contributing data varies from a few weeks to many months, again depending usually on the teacher.

INSTRUMENTATION AND SOFTWARE

Visible Light Pyranometer

Visible light is detected using a Silicon Cell Pyranometer that was designed by G. Yanow [1] [2]. While the instrument is made for the project, its commercial cost would be less than $75. Test units have been sent to the National Renewable Energy Lab., U.S. Dept of Energy, for evaluation. This instrument was judged to be able measure the visible light spectrum to an accuracy of 4.2% [3]. Other types of pyranometers that are in the price range of $2000 have a typical accuracy of about 3.5%. An instrument that can measure within 5% is considered acceptable. In practice, each school is given a refurbished and re-calibrated unit each year.

UV Sensor

The measurement of surface ultraviolet light is a far more complicated problem than the visible. It was decided to measure the UV radiation in the same manner that the UV Index is predicted. That is, based on the research done on how humans are effected by radiation in the UVA and UVB spectral regions [4]. The results of this research are illustrated in Fig. 1.

The curve shows the importance of the various UV wavelengths in their damaging effects on humans. The most sever injury comes from the UVB region (290-315 nm). However, the Earth's ozone, water vapor, smog, etc. greatly attenuate this radiation before it reaches the surface. There is much more UVA (315-400 nm) than UVB at ground level. The result is that during the summer months the UVA radiation can contribute 15-20% of skin damage [5]. It should also be noted that the published "UV index" is based on this Erythema Action Spectra curve.

Project SUN uses a filter type UV sensor made by Vital Technologies, Bolton, Ontario Canada, their model BW20.

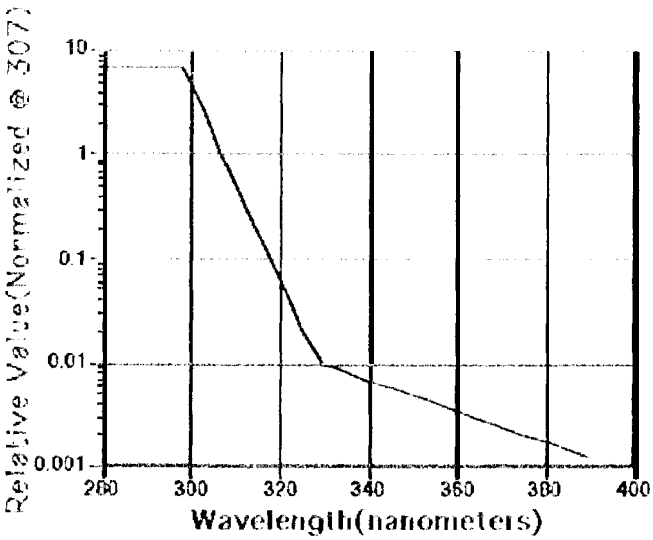


Fig. 1 Erythema Action Spectra

The BW20 was designed for Project SUN, but also now serves a wide global market. The transmission function in the filter of the BW20 very closes matches this response curve. In addition, tests at the National Institute for Standards and Technology (NIST) have shown the Vital filters to be very stable. The BW20's are also re-calibrated annually.

Calibration

The visible light pyranometers are calibrated against a Yankee TSP-1 Total Solar Pyranometer. The BW20 UV sensors are calibrated against the Vital Technologies Laboratory model BW100.

The calibration procedures are the same for both the visible and UV instruments. Data is taken comparing the SUN units against the standards every two minutes from the time period of 10:00 AM to 2:00 PM, on relatively clear days, for five days. An average calibration constant is then determined for each instrument. The standard deviation of the data must be the order of a few percent or less or the procedure is repeated until the correct tolorance is met.

The visible light is calibrated in units of watts/square-meter and the UV in milliwatts/square-meter. Note: a UV index of 1 is 25 milliwatts/square-meter--a data recording of 250 milliwatts/square-meter is therefore a UV index of 10.

However, there is currently a problem in the world of UV calibration. The Canadians first came out with a calibration based on detailed data they had taken. NIST now has also presented a calibration standard. Unfortunately, the two standards differ by about 25%, with the Canadian giving a higher reading of UV index. The current UV index predictions are based on the Canadian standard. Since this daily prediction is one of the "reality checks" used by the SUN research teams, the project has opted to stay with the Canadian standard for the time being.

Interfaces and Software

When the computers that are used as dedicated data loggers are old Apple IIe's, (two needed) modified Vernier Software (Portland OR.) VIU interfaces are used. When the data logger is made from an older Macintosh (one needed), the Vernier Serial Interface is used. Both of these units give 12 bit accuracy in the range of 0-5 VDC. In the future, researchers will be able to used older IBM's or compatibles with a Vernier serial interface.

The data logger programs, in all cases, are from Vernier Software. Yanow[2] has written conditioning software that combines the solar and UV data with a location header and local weather conditions of the day. When the data is posted in graphical form on the Home Page, four curves are presented with the locale and weather data; the visible light profile, the erythema UV profile, a profile of the ratio of visible to UV (to illustrate the skewing of the black body curve) and the predicted profile of the solar zenith angle for the location.

OPERATIONS

Overall Project

As said, Project SUN was started as a NASA/JPL pilot program. The Physics and Astronomy Dept. of the CSUN, has now formed a partnership with JPL to improve and expand the effort both in the U.S.A. and internationally. CSUN will take the lead in maintaining the Home Page and managing the data. JPL will support the instrumentation, the calibration and continue to develop the experimental protocols. JPL and CSUN will jointly do the training and analyze the data.

Current Status

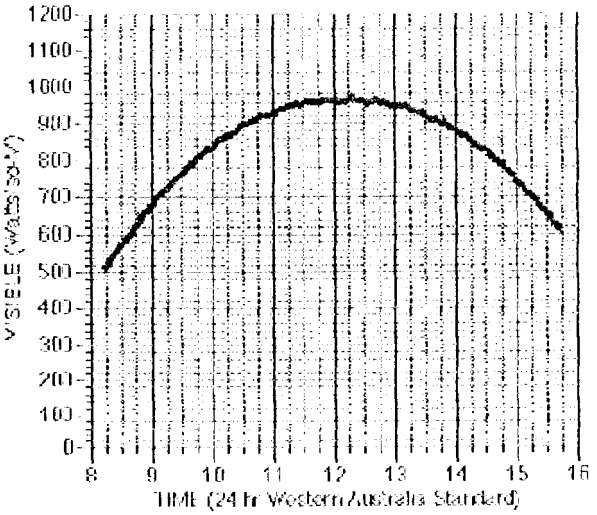
At the time of presentation, Project SUN has six schools in the Los Angeles area, one in the San Diego area, one in Michigan, one in Western Australia, one in Indonesia and one in Japan. With the help of CSUN and additional financial support (to be developed jointly by CSUN and JPL) the number of schools could greatly be increased over the next and following years.

Research Protocols

The obligation of each research team is to take SUN data at

least two days per week during the school year (special arrangements are made for the vacations times). The other days of the week, the teams are encouraged to carry out research programs of their own. Examples of this independent research have been projects to determine if a locale could develop enough electricity via photocells to support themselves, studies to determine the types of clouds that produce enhanced surface effects via cloud optics, and the correlation between humidity and UV reading. Examples of data are shown in following four figures. The conditions for the day were a maximum temperature of 97.7 degrees F, 30% relative humidity, a clear sky, with a 18 mile per hour wind from the west.

GUILDFORD GRAMMER SCHOOL, PERTH W.A. 21 NOV1996



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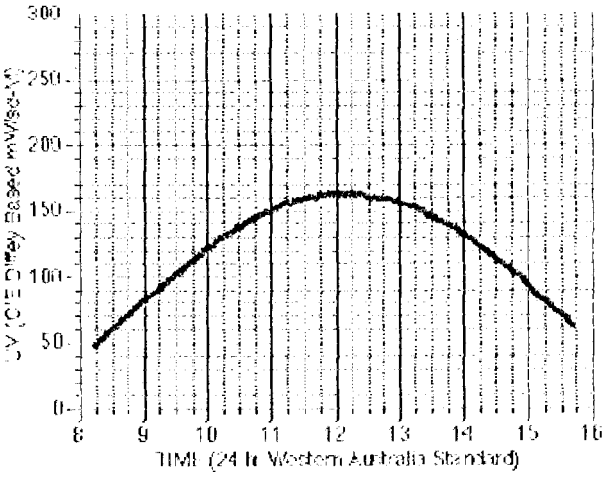

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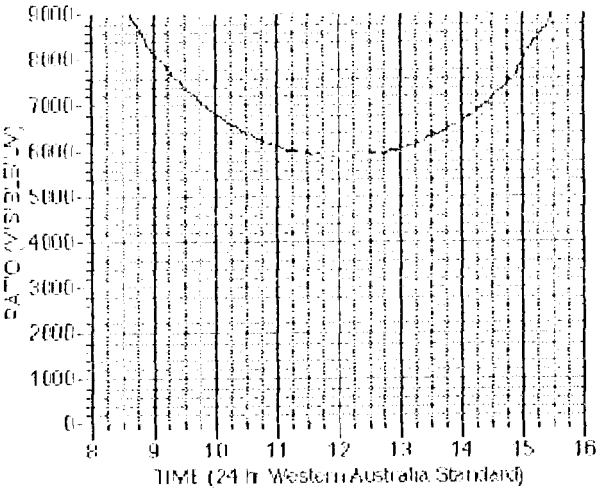

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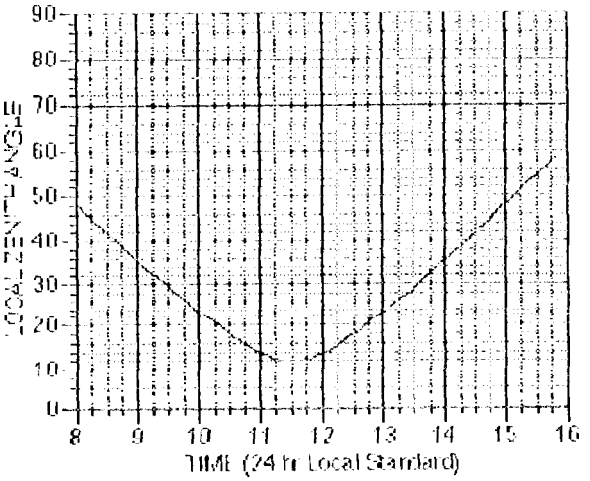

[1] Yanow, G.,"Inexpensive Pyranometer", NASA Tech Briefs. 20, 6, June 1996.

[2] Project SUN Home Page,http://sunshine.jpl.nasa.gov.

[3] Metrology Laboratory, "BORCAL 94 2", National Renewable Energy Laboratory, June 10, 1994.

[4] McKinlay, A.F. and Diffey, B.L. "A Reference Action Spectrum for Ultraviolet Induced Erythema in Human Skin", Human Exposure to Ultraviolet Radiation: Risks and Regulations, pp 83-7, 1987.

[5] Diffey, B.L., "Solar Ultraviolet Radiation Effects on Biological Systems", Review in Physics in Medicine and Biology 36(3):299-328, 1991.