UV Network News

Issue Number 2 March 2000

Welcome! to *UV Network News*, a newsletter for those involved with the UV-monitoring network operated by the U.S. Environmental Protection Agency (EPA) and the National Park Service (NPS). UV Network News is distributed monthly to provide up-to-date information on UV radiation and effects and on measurement efforts at EPA/NPS and other monitoring sites.

About the EPA/NPS UV network:

EPA and NPS operate a network of Brewer spectrophotometers at locations throughout the U.S. Fourteen of the monitoring sites are located in national parks in conjunction with PRIMENet (Park Research and Intensive Monitoring of Ecosystems Network) measurement efforts. An additional seven sites are located in urban areas. Together, these sites comprise the largest spectral-UV network in the world.

The network data are used for a variety of scientific studies including assessments of the effects of UV on frog populations and other ecosystems, verification of the NOAA/EPA UV Index for predicting human exposure levels, and for monitoring changes to the global environment. The data are available to interested parties via the following web sites:

EPA's Ultraviolet Monitoring Program, UV-Net
http://www.epa.gov/uvnet/

The National UV Monitoring Center home page
http://oz.physast.uga.edu/

The National Park Service PRIMENet page
http://www2.nature.nps.gov/ard/prime/index.htm

Biologically Effective UV

Solar radiation reaching the top of the earth's atmosphere contains radiation in the ultraviolet (100-400 nm) spectral region. UV radiation with the shortest wavelengths (100-280 nm) is referred to as UV-C radiation and is essentially blocked entirely by atmospheric oxygen and ozone. Wavelengths between 280 and 315 or 320[1] nm comprise the UV-B part of the spectrum. Radiation at these wavelengths is absorbed efficiently but not completely by atmospheric ozone, and radiation at UV-A (315 or 320 nm to 400 nm) is hardly absorbed at all. All UV radiation is blocked, to some extent, by clouds.

In recent years, stratospheric ozone has been reported to be at significant lower levels than observed in the years before 1970. These decreases in ozone may be linked to subsequent increases in the amount of UV radiation reaching the surface of the earth. Such changes are expected to be most pronounced in the UV-B part of the spectrum. The UV-B portion of the spectrum is sometimes referred to as the erythymal region since these wavelengths cause skin reddening (sunburn) known as erythema.

Because proteins, nucleic acids, and growth regulators in animal and plant cells can be broken down or affected by UV-B, increases in UV-B amounts can have pronounced biological effects. This damage has been documented despite the fact that UV-B radiation comprises only about 0.5% of the solar spectrum.

[1]The scientific community is split on whether the UVB/UVA cut-off should be 315 or 320 nm. For the purposes here, the precise point of division is arbitrary.

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Biologically effective UV (continued)

The exposure required to produce an effect, such as skin-reddening, or erythema, at each wavelength in the UV spectral region is given by an action spectrum. Action spectra provide approximate knowledge of the wavelength dependence of UV sensitivity by accounting for the increase of biological effectiveness at shorter wavelengths. This dependence, combined with the spectral nature of UV-B, results in different responses to atmospheric ozone changes for different action spectra.

Each action spectrum is represented by a graph of the reciprocal of the radiant exposure necessary to produce the effect by being studied and is normalized to the most efficacious wavelength. Action spectra are used to provide biological or hazard weighting factors for use in quantifying biologically effective UV.

The biologically effective, or hazard-weighted, UV irradiance is computed by first multiplying spectral irradiance measurements at each wavelength by a biological or hazard weighting factor as determined by the action spectrum. Summing these results over all wavelengths provides a measure of the biologically effective UV irradiance, with units W m^{-2} effective. Summing this quantity over the exposure period yields an estimate of the biologically effective radiant exposure (units J m^{-2} effective).

Knowledge of appropriate spectral sensitivity functions, or action spectra, is critical to any estimation of the biological impacts of increased UV exposure. Action spectra for a number of biological impacts have been determined in laboratory and field studies. Most of these spectra have been developed for traditional photobiological uses like determining the behavior of radiation-absorbing pigments or molecules.

The spectra are usually obtained by exposing biological material to a single wavelength (or narrow range of wavelengths) at a time and measuring the effect. The spectra are traditionally developed after some number of hours of UV exposure at each wavelength.

In nature, organisms are exposed simultaneously to radiation at all wavelengths over periods of days, months, or longer. Because of the constraints imposed by practicality, laboratory measurements of action spectra present some limitations for accurate determinations of biologically effective radiation levels. Still, the information they provide leads to more appropriate calculations than if unweighted UV-B radiation were used on its own.

Detailed explanations of action spectra and biologically effective UV radiation are provided by the references below. Madronich et al. (1995 and 1998) also present a list of references providing action spectra measurements for various UV effects.

References:

1. WHO Environmental Health Criteria No. 160: Ultraviolet Radiation, 1994, 352 pp.

2. Madronich, et al. Changes in ultraviolet radiation reaching the earth's surface. *Ambio* 24(3):143-152, 1995.

3. Madronich et al. Changes in biologically active ultraviolet radiation reaching the earth's surface. *J Photochem Photobiol B* 46:5-19, 1998.

*UV Effects Research: Amphibians**

One of the goals of the current interagency agreement between the U.S. EPA and the NPS is to support research concerning UV effects on amphibian populations. In 1999, national parks in the PRIMENet system rated amphibian monitoring as one of their top ten research needs. Scientists seek to answer questions such as

- what factors influence UV levels in amphibian habitats?, and
- are currently observed UV levels potentially harmful to amphibians?

During the past decade, amphibian populations worldwide have experienced unexplained declines. Many of these declines have been observed in mountain regions where possible increases in UV radiation due to ozone depletion are expected to be most acute. UV-B radiation has been cited as a potential contributor to mortality and malformations in certain amphibian species, despite the current lack of published field data linking changes in amphibian populations with observed environmental UV doses.

The possibility of a link between changing UV levels and amphibian populations is supported by numerous laboratory studies documenting the capacity of UV-B radiation to directly impact DNA and other macromolecules in a variety of amphibian species. It is also generally accepted that the early life stages of amphibians are particularly susceptible to damage by UV-B radiation. However, not all studies of UV effects on amphibians have recorded mortality or deformity in embryos exposed to current levels of UV radiation. Amphibians may also by excluded naturally from certain high-exposure environments, including small, clear ponds at high elevations in the Alps of Europe.

Knowledge of the UV radiation reaching amphibian populations requires determination of the aquatic UV dose, consisting of the terrestrial UV dose combined with the transmission of light in the aquatic environment. A myriad of other factors, including stratospheric ozone variations, weather, and local shading and topography can also affect UV levels reaching amphibians. The required field observations can only be obtained through monitoring of UV-B intensity at the habitat level. These measurements can then be combined with data collected in regular surveys of amphibians within the habitat.

Combined UV intensity/amphibian population surveys are being conducted at Sequoia-Kings Canyon, Olympic, and Glacier national parks, all of which are current PRIMENet sites. The measurements include water column UV extinction as well as data related to wetland location and dimension, pH and temperature of the water, and documentation of amphibian species and stages. Water samples and UV measurements are also being collected in Rocky Mountain, Acadia, and Great Smoky Mountains national parks. These measurements will provide estimates of the variability of UV doses in habitats across North America.

*based on PRIMENet UV/Amphibian Populations Research Planning Workshop Final Report, 1999. P. Trenham, S. Diamond, N. Detenbeck, and G. Ankley.

A list of selected UV and amphibians references is provided on page 4.

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Some recent papers highlighting amphibian UV-effects:

Ankley et al. Effects of ultraviolet light and methoprene on survival and development of *Rana pipiens*. *Environ Toxicol Chem* 17:2530-2542, 1999.

Blaustein et al. UV repair and resistance to solar UVB in amphibian eggs: A link to population declines? *Proc Nat Acad Sci*, 91:1791-1795, 1994.

Blaustein et al. Ambient ultraviolet radiation causes mortality in salamandar eggs. *Ecol Appl* 5:740-743, 1995.

Blaustein et al. Ambient UV-B radiation causes deformities in amphibian embryos. *Proc Nat Acad Sci*, 94:13735-13737, 1997.

Corn. Effects of ultraviolet radiation on boreal toads in Colorado. *Ecol Appl* 8:18-26, 1998.

Cummins, et al. A test of the effect of supplemental UV-B on the common frog, *Rana temporaria*, during embryonic development. *Global Change Biol* 5:471-479, 1999.

Grant and Licht. Effects of ultraviolet radiation on life-history stages of anurans from Ontario, Canada. *Canad J Zool*, 73:2292-2301, 1995.

Hays et al. Developmental responses of amphibians to solar and UVB sources: A comparitive study. *Photochem Photobiol*, 64:449-456, 1996.

Long et al. A pH/UV-B synergism in amphibians. *Conserv Biol*, 9:1301-1303, 1995.

Nagl and Hofer. Effects of ultraviolet radiation on early larval stages of the alpine newt, *Triturus alpestris*, under natural and laboratory conditions. *Oecologica* 110:514-517, 1997.

In future issues:

An Overview of the Central UV Calibration Facility

UV and Plants

Skin Cancer and Cataract Facts

Don't forget to visit the Internationally Coordinated UV Radiation Page at http://www.srrb.noaa.gov/UV/. The site also contains archived issues of *UV Network News*.

Your contributions and suggestions for future articles or news stories are always welcome.
Please contact Betsy (betsy@srrb.noaa.gov) or Amy (amy@srrb.noaa.gov) with any suggestions.

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- Any comments or contributions are welcome. -