Amounts of Ozone-Depleting Halocarbons in the Atmosphere

Halocarbons are molecules containing one or more atoms of a halogen (chlorine, fluorine, bromine, or iodine). Some of these compounds are human made, and were developed to be largely chemically inert. These human-made halocarbons have long atmospheric lifetimes and, as a result, can reach the stratosphere and cause trouble for ozone.

Although some halocarbons can be broken down prior to reaching the stratosphere, the only significant sink for the substances is breakdown by solar ultraviolet radiation at stratospheric altitudes. This breaking apart releases free atoms of chlorine and bromine into the stratosphere where each can destroy many molecules of ozone.

Production of these ozone-depleting substances has been limited by the Montreal Protocol. The Protocol was originally signed in 1987 and represents a landmark international agreement to protect the environment. Amendments to strengthen the Protocol were adopted by some of the countries in 1990, 1992, 1995, and 1997. The Protocol and its amendments mandate a phase-out of chlorofluorocarbon production by 2000 and of methyl chloroform by 2005. Production of hydrochlorofluorocarbons (HCFCs), currently used as interim replacements for CFCs, is prohibited in developed countries after 2030.

Compliance with and success of the Protocol can be determined through measurements of halocarbons in the atmosphere. The atmospheric burden of the halocarbons taken in total can be expressed in terms of "effective equivalent chlorine" (EECl). NOAA Climate Monitoring and Diagnostics Laboratory scientists Stephen Montzka and co-authors published a paper indicating that by the end of 1997, EECl had decreased by only about 3% of the total atmospheric burden. The decrease stems primarily from a decline in trichloroethane (CH_3CCl_3), a previously common cleaning solvent with an atmospheric lifetime of about 5 years.

The decrease of EECl has been slowed most significantly by the halon H-1211. H-1211 contains bromine, which contributes to significant ozone destruction. Montzka et al.'s results show that, contrary to industry estimates, annual H-1211 emissions during 1992-1997 were similar to those estimated for the late 1980s. These emissions continue despite the availability of alternatives for most uses and despite efforts to halt production, limit use, and recover and recycle the halon. Continued emission of H-1211 at 1997 rates would increase the total burden of EECl over the next 5-10 years by as much as 3-5% over the amounts expected if emissions were eliminated in 2000.

Clearly, adherence by all countries to the Montreal Protocol is imperative for the continued decline of halocarbon emissions and the eventual recovery of the ozone layer. The work is ongoing, and following are some good references to visit for further information:

Anderson, J. et al. Halogen Occultation Experiment confirmation of stratospheric chlorine decreases in accordance with the Montreal Protocol, J. Geophys. Res., 105:4483-4490, 2000.

Montzka, S.A. et al. Present and future trends in the atmospheric burden of ozone-depleting halogens, Nature 398:690-694, 1999.

Turco, R.P. Earth under siege: from air pollution to global change, Oxford U. Press, 1997.

World Meteorological Org., Scientific Assessment of Ozone Depletion: 1998, Rep. 44, WMO, 1999.

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- Any comments or contributions are welcome. -

UV Network News

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Welcome! to *UV Network News*, a newsletter for those involved with the UV-monitoring network operated by the U.S. Environmental Protection Agency (EPA), the University of Georgia's (UGA) National UV Monitoring Center (NUVMC), 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/UGA and other monitoring sites.

About the EPA/UGA UV network:

EPA, UGA, 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

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Photo from U.S. Geological Survey.

Photo from Environment Canada.

UV Biological Effects Research— Northern Leopard Frog

The Environmental Protection Agency and the National Park Service are studying the biological effects of UV radiation through both laboratory experiments and field surveys. 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.

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, but other factors, including pollution, viruses, and habitat destruction, can also play a role.

Field experiments are currently underway to measure 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 how UV doses vary among habitats across North America.

In addition to the field experiments, work is in progress to study the effects of UV radiation on amphibians through laboratory experiments. 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. These studies provide evidence that the early life stages of amphibians are particularly susceptible to damage by UV-B radiation.

Studies by scientists at the EPA's Mid-Continent Ecology Division have explored the effects of ultraviolet radiation and natural sunlight on the northern leopard frog. This species had been previously observed to develop malformations, or to experience increased mortality rates, when exposed to artificial sources of UV (Ankley et al., 1998). The most recent work included both artificial UV and natural sunlight sources, and indicated significant negative effects in terms of malformations and increased mortality.

The researchers found that animals exposed to UV radiation in the laboratory over time, from just prior to hindlimb development through forelimb emergence, exhibited hindlimb malformation. The malformations consisted primarily of missing and reduced digits, and tended to be dose-dependent. Likewise, exposure of animals at this life stage to full intensity natural sunlight caused significant mortality, while exposure to screened sunlight (50-60% of ambient) resulted in an elevated incidence of abnormal hindlimb pathology identical to that observed in organisms exposed to UV radiation in the laboratory.

Extension of these results to the field is complicated by uncertainties in extrapolating the dose information in the context of animal behavior. The potential significance of these lab studies in explaining adverse effects observed in amphibians in the field is as yet unclear.

References:

Ankley G.T., et al. 1998; Environ. Toxicol. Chem. 17:2530-2542.

Diamond, S.A. and P.C. Trenham 2000; Coordinated Studies of UV and Amphibian Distributions, PRIMENet Annual Meeting.

Trenham P.C., et al. 1999; Ultraviolet Radiation/ Amphibian Populations Research Planning Workshop. Workshop.

Brewers Around the World

The EPA/UGA network is the largest network of UV spectrophotometers in the world. It is, however, only one of the Brewer UV monitoring networks currently in existence. Networks are also operational in Canada and Japan, and other instruments are measuring UV in several locations, including Italy, Germany, Brazil, Switzerland, and Australia.

The Brewer instrument has been in use since the early 1980s. Over the years, its only world manufacturer has been SCI-TEC Instruments Inc. of Saskatoon, Canada. SCI-TEC was founded in 1981 and in December 1996 completed a merger with Kipp & Zonen. Current company reports indicate that over 165 Brewers are in operation in 43 countries and in Antarctica.

Canada operates a total of 13 Brewers at sites throughout the country. The sites are located as far north as Alert (82.5ºN) and are often co-located with ozonesonde observations. The measurements, including information on sulfur dioxide and UV, are collected through the Brewer Data Management System (BDMS). The system was developed by Canada's Atmospheric Environment Service to collect, archive, and process the raw Brewer data. More information and links to the Canadian Brewer network are available at http://www.srrb.noaa.gov/UV/country/canada.html.

The Japan Meteorological Society maintains a network of five Mark II Brewer instruments, measuring over the 290 to 325 nm range. Four are currently located in Japan while one is operated in Antarctica. The National Institute for Environmental Studies operates an additional Brewer in Tokyo to evaluate UV doses and changes in an urban area. The Japanese observations have been made routinely since the early 1990s. For information and links, visit http://www.srrb.noaa.gov/UV/country/japan.html.

The Brewer observations are archived at the World Ozone and UV Data Centre (WOUDC), located in Toronto. The WOUDC archives ozone and UV data, including Brewer data, from stations world-wide. Data and information are available from their web site at www.msc-smc.ec.gc.ca/woudc/. Work is in progress to archive the processed EPA/UGA data here, probably beginning in the middle of next year.

The University of Southern Queensland (USQ) in Australia currently has a Brewer Mark III in operation to collect spectral UV measurements. Brewer instruments are also operated by the Italian Meteorological Service, the Swiss Meteorological Service, the Malaysian Meteorological Service, the Central Weather Bureau of Taiwan, and other agencies.

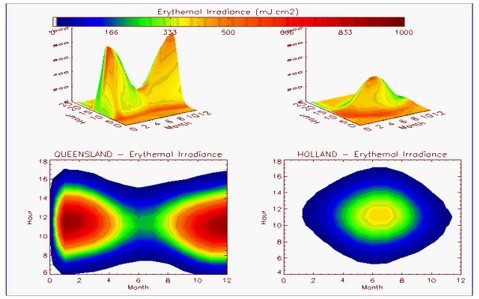

Figure 1. Modeled UV levels in Queensland and Holland, provided by Michael Kimlin (kimlin@usq.edu.au).

Worldwide UV monitoring is necessary to improve our understanding of variations and changes worldwide. As shown in Figure 1, the UV irradiance in Queensland, Australia during winter is approximately the same as that for summer in Holland. Globally, the amounts of UV received, and changes in these amounts, are not the same in all locations, and can be greatly affected by cloud cover, pollution, and other variables.

More information on UV monitoring around the world, including networks using instrumentation other than the Brewer, is available from the UV Radiation site at http://www.srrb.noaa.gov/UV/. The pages are continually being updated; please email betsy@srrb.noaa.gov or amy@srrb.noaa.gov with any additions or changes.