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CURRENTS in Science, Technology, & Society

Tracking the Ozone Layer

By Forrest M. Mims, III

What Is the Ozone Layer and How Does It Affect You?

Forrest Mims is a science writer with over 500 articles and more than 70 books to his credit. Among his accomplishments is the invention of a hand-held instrument that measures atmospheric ozone. For this accomplishment, Mims won a 1993 Rolex Award, which included a cash prize of 50,000 Swiss Francs (about $30,000). Mims used his prize money to produce about 30 instruments, which have become part of the Sun Photometer Atmospheric Network (SPAN) — a worldwide network that has been set up to monitor ozone. For more information about SPAN, write to Mims at 433 Twin Oak Road, Seguin, TX, 78155. For more information about his instrument, called MicroTOPS, contact Advanced Concept Electronics, 116 W. 19th Street, POB472, Higginsville, MO 64037-0472. The phone number is (816) 584-7121.

Mims has measured ultraviolet radiation and the thickness of the ozone layer almost daily since 1989.

Sprinkled throughout the atmosphere are pale blue molecules of a toxic gas that are essential to most life on Earth. This gas is ozone.

Ozone is toxic because it is highly reactive. This is why it can sterilize drinking water, eliminate odors, bleach colors, and decompose rubber. Fortunately, the amount of ozone at ground level is usually too low for these effects to be observed. However, high concentrations of various air pollutants and sunlight can increase ozone levels near the ground from a few tens of molecules per billion molecules of air (ppb) to a few hundred ppb. These levels of ozone can damage plants, cause eye irritation, inflame mucous membranes and impair the performance of athletes.

Ozone is essential to life because it shields the Earth from the damaging, even lethal, ultraviolet radiation emitted by the sun. This filtering ability is particularly remarkable when you consider the relative scarcity of ozone molecules. For every billion molecules in the atmosphere, only around 300 are ozone.

Imagine you could poke a tube through the entire atmosphere over your head and bring all the ozone molecules in the tube down to the surface. If they were then subjected to the same temperature and atmospheric pressure (standard temperature and pressure or STP) as you are, they would form a layer only about 3-millimeters thick.

Although they may be formed in many different ways, all the ozone molecules in the stratosphere are identical. An oxygen molecule (O_2) is composed of two oxygen atoms (O). Ultraviolet radiation can split an O_2 molecule and leave behind two free O atoms. Various chemical reactions leave O atoms as a byproduct. In either case, the free O atom can merge with an O_2 molecule to form triatomic oxygen (O_3), more commonly known as ozone.

The Two Ozone Layers

The term “ozone layer” generally refers to a relatively high concentration of ozone in the stratosphere, a layer of very dry air around 15 to 35 kilometers (9 to 22 miles) above the Earth’s

In this issue:

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surface. However, about 10 percent of the total ozone is found in the troposphere, the lowest portion of the atmosphere. The troposphere contains 90 percent of the atmosphere and nearly all of the atmosphere's water vapor. Storms form in the troposphere and usually stay there. But the tops of especially powerful thunderstorms occasionally poke into the lower stratosphere.

The tropopause, the border between the troposphere and the stratosphere, ranges from around 10 to 15 kilometers above the surface. The heat of summer increases the height of the tropopause; the height is reduced in winter.Other things being equal, when the tropopause is low, the amount of stratospheric ozone is high and vice versa.

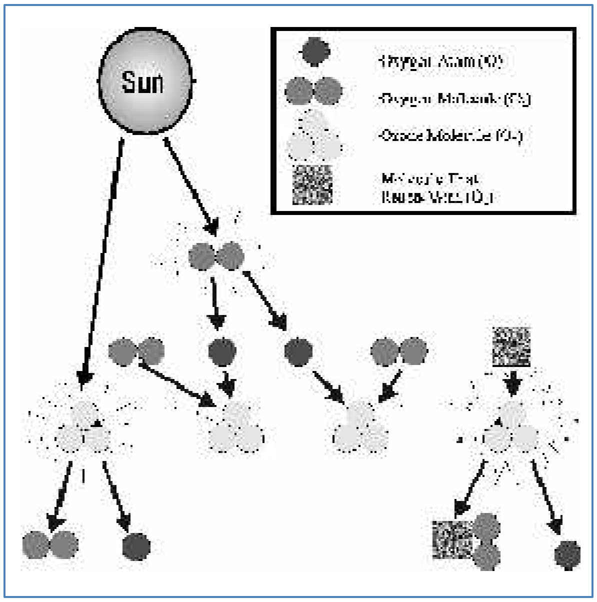

Figure 1. A simplified view of how ozone molecules can be formed and destroyed.

Tropospheric Ozone

The ozone between the surface and the tropopause forms only a fraction of the ozone over most locations. Nevertheless, it absorbs solar UV more efficiently than an equal amount of stratospheric ozone. This is because scattering caused by dust and aerosols increases the distance that rays of sunlight travel on their way to the surface. In spite of this benefit, tropospheric ozone is often referred to as "bad" ozone because of its adverse effects in high concentrations. If the same ozone were somehow to drift into the stratosphere, it would be called "good" ozone.

Forming and Destroying Tropospheric Ozone

Tropospheric ozone is produced in many ways. Some is formed by lightning or by UV radiation from the sun. Most is formed by chemical reactions which take place in the presence of sunlight.

One such reaction is the conversion of nitrogen dioxide (NO_2) into nitrogen oxide (NO) in the presence of solar UV. The O atom left over from this reaction combines with an O_2 molecule to form an ozone molecule. Various other gases in the atmosphere can combine with NO to form more NO_2, which then can cause a buildup of ozone. Gaseous organic chemicals, in the presence of nitrogen oxides and sunlight, can also contribute to ozone production.

The same photochemistry that forms ozone can also destroy it. Indeed, some photochemical processes in the atmosphere are called "do-nothing" reactions since they destroy as much ozone as they create. Ultraviolet radiation leaking through the ozone high in the stratosphere can also create and destroy ozone in the troposphere.

Measuring Tropospheric Ozone

There are several ways to measure tropospheric ozone. Since ozone is a strong oxidizer, it changes the color of some chemical compounds and solutions. For example, paper soaked in a mixture of starch and potassium iodide will change color when exposed to ozone.

The reaction of ozone with various chemicals, gases, and even some lubricating oils causes a faint luminescence that can be detected by a sensitive photomultiplier tube. Detection systems such as this are known as chemiluminescence detectors.

Since ozone absorbs ultraviolet radiation so effectively, many kinds of ozone detectors incorporate a UV lamp and a detector. Air is passed through a chamber, and any attenuation is assumed to have been caused by ozone. A problem with this method is that attenuation can also be caused by dust. Therefore, it's common practice to use two chambers, one of which receives air from which any ozone has been scrubbed by a catalytic converter. Alternatively, scrubbed and unscrubbed air can be passed in sequence through the same chamber. Either way, the error caused by dust and other contaminants in the ozone-free sample can then be determined by subtraction.

Sulfur dioxide and other chemicals can interfere with the chemical and UV detection of

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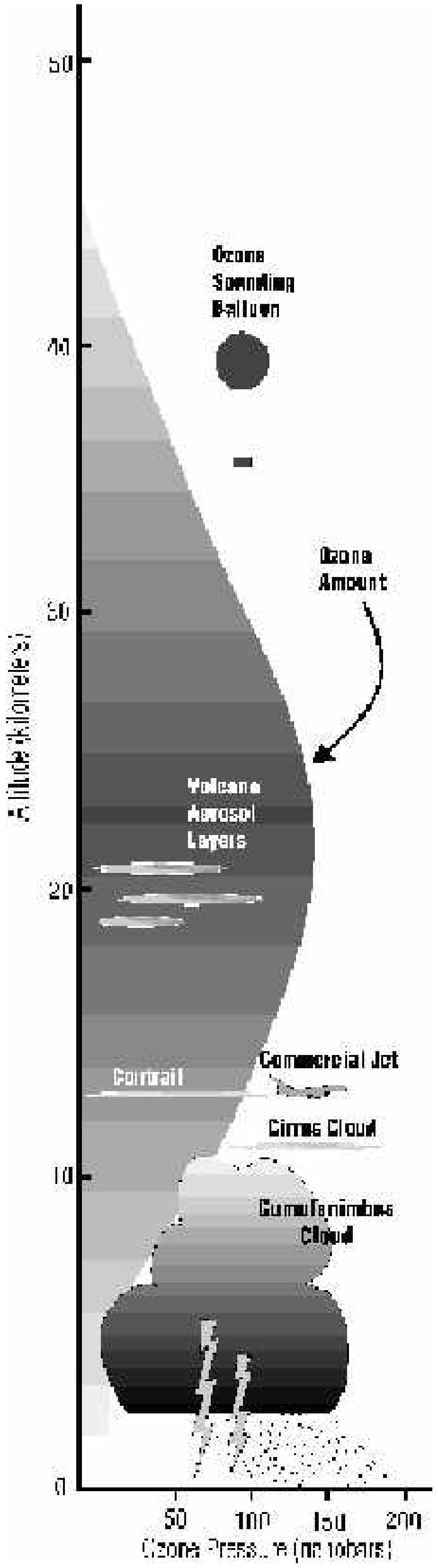

Figure 2 . How ozone is distributed in the atmosphere.

ozone. When scientists at the Montsouris observatory near Paris became aware of this problem in 1905, they built a second chemical ozone detector. The air inlet for the new detector was fitted with a 4-meter (13-feet) hose of natural rubber, which completely destroyed any ozone passing through it. In this way any errors in the original detector caused by gases other than ozone could be eliminated.

Several times my son Eric and I have measured the amount of tropospheric ozone between the bottom and top of mountains in New Mexico. We do this by measuring the total amount of ozone in the atmosphere with a UV-sensitive instrument that is pointed at the sun. One of us goes to the top of a mountain while the other stays at the base. We then make a series of observations at prearranged times. Later, we subtract the ozone measured at the mountaintop from the measurements made at the base to determine the amount of ozone in between. So far our results (a few Dobson Units per vertical kilometer; see Figure 5) have agreed with measurements made from balloons by the National Oceanic and Atmospheric Administration (NOAA).

Tropospheric Ozone Cycles

The amount of ozone above any given spot of Earth is rarely constant. Consider the diurnal or daily ozone cycle over Albuquerque, New Mexico.

Early on a July morning at the base of the Sandia Mountain aerial tramway just northeast of the city, ground-level ozone concentration might be, say, 20-30 ppb. As the sun rises high in the sky, photochemical ozone production increases, especially when the wind is from the southwest and the clean mountain air is spiked with nitrogen oxides and hydrocarbons from automobile exhaust. Although little or no photochemical smog may be visible, the ozone concentrations might reach 40-60 ppb by late afternoon. As the sun sinks behind the volcano cinder cones west of Albuquerque, the ozone level also falls. Late that evening, the ozone returns to its normal "background" level.

Tropospheric Ozone Trends and Effects

The ozone measured at the ground near Paris, France, from 1876-86 was only around a third to a half of what is usual in unpolluted areas today. The increase since then is generally believed to be caused by human activities. At least two-thirds of the nitrogen oxides are believed to come from the burning of fossil fuels, wood, forests and agricultural wastes. Nitrogen

A government official who makes ozone measurements at fixed sites told me that ozone levels can be much higher in the air over New York and in the surrounding regions than at ground level in the city. Apparently the high number of air pollutants, people, rubber tires, and the like, suppresses ozone concentrations at street level.

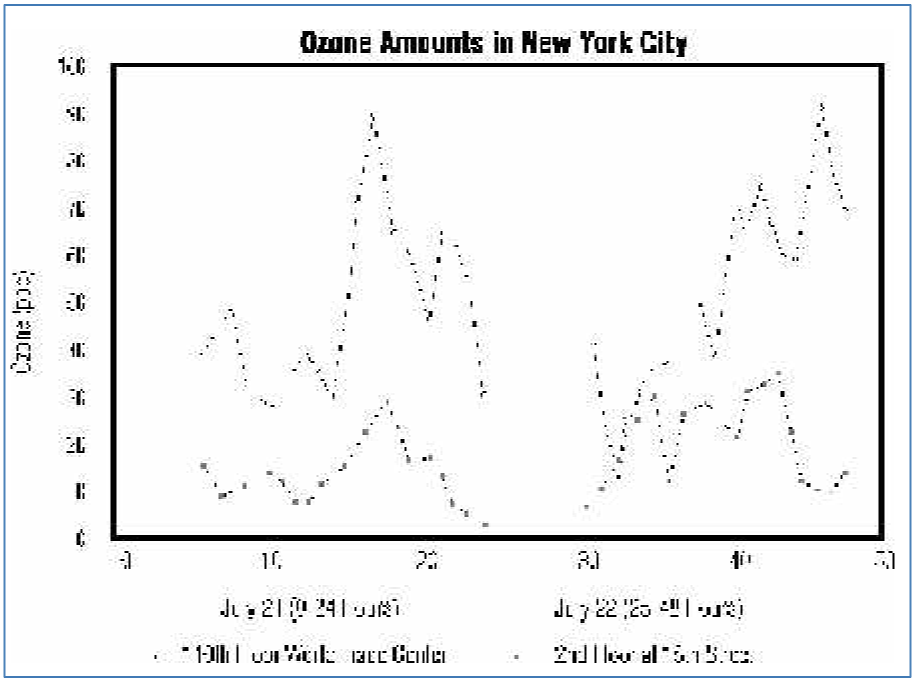

Figure 3 . Ozone levels near street level and at the 110th floor of the World Trade Center in New York City on July 21, 1989.

oxides are also produced naturally by lightning, forest fires, and soil. Organic chemicals, such as methane and hydrocarbons, can be byproducts of plants, animals, and human activity.

It's interesting to compare the amount of ozone in a vertical column of air adjacent to a mountain with that over a city. In the summer of 1989, Eric and I measured 5.8 DU (Dobson Units) of ozone between the base and crest of Sandia Mountain, an altitude difference of 1,164 meters (3,819 feet). A few weeks earlier I had measured about 5 DU of ozone between street level and an observation deck atop the 110th floor of the World Trade Center in New York City (420 meters or 1,377 feet). There was much more ozone in the air above New York City than in the air near Sandia Mountain.

Surprisingly, however, much of the air at street level has less ozone than you might expect. A government official who makes ozone measurements at fixed sites told me that ozone levels can be much higher in the air over New York and in the surrounding regions than at ground level in the city. Apparently the high number of air pollutants, people, rubber tires, and the like, suppresses ozone concentrations at street level.

When California forced a significant reduction of hydrocarbon emissions from automobiles, the ozone in downtown Los Angeles fell. Ozone levels downwind, however, continued to rise. The scientists who puzzled over this dilemma noticed that there is considerably more vegetation downwind from the central city. They concluded that ozone is reduced only when both hydro-carbons and nitrogen oxides are reduced.

The relationship of trees and ozone is particularly interesting. Too much ozone can damage or even kill trees. Ironically, trees emit hydrocarbons that participate in chemical reactions that produce ozone. Several years ago William Chameides of the Georgia Institute of Technology studied satellite images of Atlanta and found that 57 percent of the city was wooded. He and his co-workers concluded that Atlanta's trees emitted at least as many hydrocarbons as the city's cars, trucks, buses and factories.

Stratospheric Ozone

Most references to the ozone layer mean the ozone found in the stratosphere. There it forms a vaporous shield that protects life on Earth from the lethal effects of the sun's UV radiation. If you've flown in the Concorde, then you have probably travelled through the bottom of the stratospheric ozone layer.

Forming and Destroying Stratospheric Ozone

Ozone in the stratosphere is formed by a natural photochemical process when ultraviolet radiation from the sun splits molecules of oxygen into the individual oxygen atoms from which they are formed. The free O atoms soon react with O_2 molecules to form O_3.

This process works both ways: O_3 molecules that are unlucky enough to be struck by UV radiation are split back to an O_2 molecule and a free O atom. The free O atom can merge with an O_2 molecule to once again form an O_3 molecule.

Ozone molecules that drift lower down in the stratosphere are protected from the destructive effects of UV radiation by the overlying blanket of ozone molecules. But even molecules of ozone deep in the ozone layer are not entirely safe, for they can be destroyed by reactions involving sunlight and oxides of nitrogen, hydrogen, chlorine, and bromine. Although all these chemicals can arise from natural sources, they can also arise from human activity. For example, manufactured chlorofluorocarbons (CFCs) have been a concern since 1970 when James E. Lovelock detected their presence in air. In 1974, Sherwood Rowland and Mario Molina proposed that CFC molecules could eventually drift into the stratosphere, where UV radiation would break them down into chlorine monoxide (ClO) and other ozone-destroying compounds.

In recent years, evidence has been accumulating that CFCs may indeed be causing a gradual reduction of ozone, particularly in regions near the poles during early spring. The question now being researched is how much ozone they might ultimately destroy. Fortunately solar UV is constantly creating new ozone. Therefore, CFCs cannot destroy all the ozone.

Measuring Stratospheric Ozone

Ozone in the stratosphere can be measured directly using instruments on aircraft, rockets, and–especially–balloons. Many of the same kinds of sensing systems used for measuring ozone at the surface have been modified for these roles.

Thanks to ozone's well-known ability to absorb ultraviolet radiation, the total amount of ozone (troposphere plus stratosphere) can be measured indirectly from the surface or from space. Several kinds of optical instruments have been developed for measuring ozone from the surface, including the Dobson spectrophotometer and various instruments that use filters or diffraction gratings to measure narrow bands of ultraviolet.

The Dobson spectrophotometer plays a key role in ground-based ozone monitoring efforts. Invented in the late 1920's by G. M. B. Dobson, this instrument divides sunlight into a spectrum with a prism and measures the ratio of two UV wavelengths about 20 nanometers (nm) apart. Dust and aerosols can cause errors in ozone observations by scattering one wavelength more than another. Dobson observations are usually made at two pairs of wavelengths to cancel out this error.

The Dobson instrument is expensive, nearly 2 meters (6 ft) long, and heavy–about 40 kilograms (85 pounds). Since it measures the ratio of two or more ultraviolet signals, it provides no information about the amount of solar ultraviolet.

The Brewer ozonometer uses a diffraction grating to separate the sun's ultraviolet wavelengths. (A diffraction grating consists of several parallel grooves that split light up into several wavelengths. A compact disk produces an effect much like a diffraction grating–except that the rainbow colors are produced by parallel rows of pits instead of grooves.) This expensive instrument is smaller than the Dobson and well-suited for automated data taking. It also measures sulfur dioxide, a gas that can interfere with ozone measurements. Some scientists believe that the Brewer measures ozone with higher precision than the Dobson. Indeed, Canada has switched from Dobsons to Brewers.

A third kind of instrument uses optical filters to measure two or more UV wavelengths. Such instruments are cheaper, smaller, and easier to use than the Dobson and the Brewer. They also provide information about the sun's direct ultraviolet. For these reasons, I selected the filter approach when designing an instrument to measure total ozone several years ago.

Some sensors on satellites can measure the amount of ozone at various altitudes by observing the sun as it rises and sets through the atmosphere above the Earth's limb (an astronomical term referring to the edge of a planetary body's disk). Other satellite sensors measure the amount of the sun's ultraviolet that is scattered back into space from the atmosphere below. Since these wavelengths are absorbed by ozone, processing the backscatter from one or more pairs of wavelengths permits one to estimate the amount of ozone between the satellite and the ground.

It's important to note the latter kind of instrument cannot measure all the ozone between the top of the atmosphere and the surface. Clouds can get in the way, and little or none of the UV backscattered from the lowest few kilometers above the surface can penetrate back through the ozone layer. An estimate of lower tropospheric ozone is added to the satellite ozone equation to correct this problem. The estimate is based on measurements made from the ground during annual calibration checks and measurements made by balloon sensors.

Stratospheric Ozone Cycles

Superimposed on the daily ozone cycle near the ground are seasonal changes in the amount of stratospheric ozone. In the northern hemisphere, the total amount of ozone is lowest during winter. The amount of ozone begins to rise rapidly during spring and gradually diminishes in the summer and fall.

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This gradual seasonal variation in ozone is marked by sharp spikes and dips associated with weather systems. Passage of a cold front, for example, may cause the amount of ozone to increase 20 percent or more for a day or two. A warm front may cause an comparable decrease. Meterologists refer to regions of diminished ozone as ozone minimums, and regions of high ozone as ozone maximums.

I'll never forget the giant ozone maximum that passed over South Texas on March 16, 1990 (See Figure 6, page 8). That morning I made a few ozone observations around 11:00 a.m. and was surprised to find the highest amount of ozone I had ever measured, around 360 DU. Since the ozone amount kept climbing as noon approached, I assumed something was wrong with the instrument. But both filters were clean, no wires were dangling in front of them, and the battery was fresh.

After 1:00 p.m. the ozone amount climbed even faster than it had before noon. By 1:30 p.m. it was more than 440 DU and shortly before 2:00 p.m. it reached 460 DU. The ozone amount then began a sharp slide to pre-noon levels.

Several months later, data from the TOMS (Total Ozone Mapping Spectrometer) instrument aboard the Nimbus-7 satellite confirmed the extraordinarily high ozone levels of March 16. My son Eric wrote a Pascal program that transformed the TOMS data into a color-coded ozone map of the United States. The map disclosed an enormous tongue of high ozone reaching down from Canada and ending in South Texas. A check of weather records revealed that this ozone maximum was associated with a giant weather system that moved in from the Pacific and crossed the United States over a 3-day period.

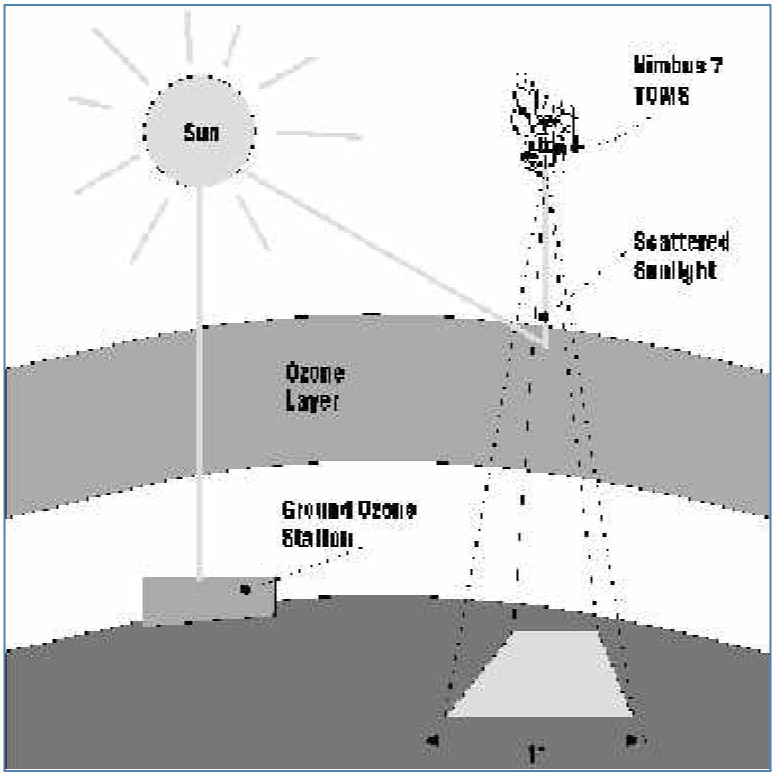


Figure 4 . How ozone is measured from space and the ground.

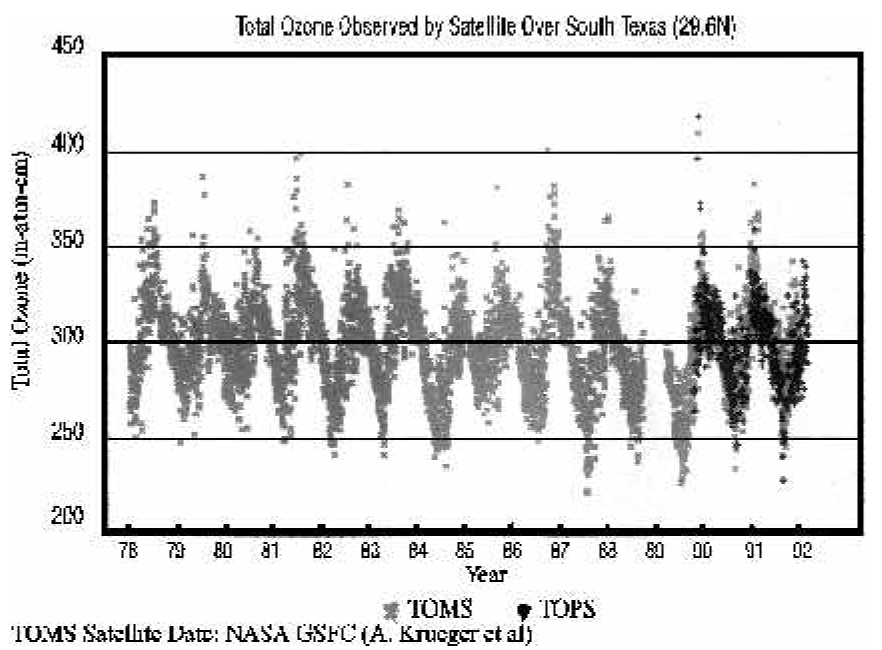
Stratospheric Ozone Trends and Effects

Recall that most ground observations of the ozone layer measure the total amount of ozone in a column between the instrument and the top of the atmosphere. Therefore, these measurements include the total amount of both tropospheric and stratospheric ozone.

Daily measurements of the amount of total column ozone have been made at Arosa, Switzerland since 1926. The total amount of ozone back to 1912 has been determined by a careful analysis of solar measurements made by the Smithsonian Institution. Since 1957, more than 70 Dobson spectrophotometers have made regular measurements of ozone.

These measurements show that the total amount of ozone varies in cycles that may last a decade or more. For example, during the 1960's, scientists at NOAA found that ozone over North America increased by about 5 percent. Since 1970, however, ozone over the northern hemisphere has declined around 5 percent. Since this decline is seen in both measurements from the ground and from satellites, there is little disagreement that it is real. But there is considerable disagreement concerning the reason for the decline, and its significance.

Some scientists believe the decline is primarily a byproduct of natural meterological cycles, a changing climate and possibly the solar cycle. They support their case by pointing to ozone cycles over the past 50 or more years. Others believe the decline is in large part caused by contamination of the atmosphere by pollutants that contribute to the destruction of ozone–



TOMS Satellite Data: NASA GSFC (A. Krueger et al)
TOPS - 1: Forrest M. Mims, III

Figure 5 . Annual cycles are obvious in this graph of the total ozone in South-Central Texas from November 1, 1978 to May 25, 1992. Light gray represents Nimbus-7 satellite observations. Dark gray represents observations by Forrest Mims, III using TOPS-1. (Satellite observations shown here for 1989 are incomplete and may be 8% too low.)

particularly CFCs. Some believe the eruption of major volcanoes such as El Chichon in 1982 and Pinatubo in 1991 exacerbate the problem. Still others believe ozone is impacted both by natural meteorological trends and ozone-destroying chemicals.

These issues are being studied and debated by the scientists who study ozone. Meanwhile, as has been widely reported in the press, there has been considerable political fallout over the issue of declining ozone.

That’s one reason why more than 70 nations have signed the Montreal Protocol, an agreement to eventually ban production of most CFCs. Because it is believed that CFSs can remain in the atmosphere for decades, even a total ban will not restore the ozone to its pre-1970 condition–if indeed CFC’s are the principal culprit. Instead, ozone will continue to decline at, perhaps, a few percent or so per decade until CFCs are no longer present.

Ultraviolet Radiation

If the spectral sensitivity of a honey bee’s eyes could somehow be added to yours, rainbows would have an additional streak of color adjacent to the violet band. This invisible band of “black light” is known as ultraviolet radiation.

Ultraviolet radiation is divided into three bands. The wavelengths below 290 nm are referred to as UV-C. The wavelengths between 290 and 320 nm are referred to as UV-B. And the wavelengths between 320 and 340 nm are known as UV-A. The ozone layer blocks all UV-C. The UV-B that leaks through is what causes sunburn.

The Ultraviolet Sky

The sky is blue because most of its molecules are just the right size to scatter the blue wavelengths of sunlight. These molecules also scatter UV wavelengths. This means that the entire daytime sky is a gigantic source of UV-A and UV-B (remember that all the UV-C is absorbed by ozone).

The UV radiation from the sky can be described as direct, diffuse, or global. Direct radiation is that which comes directly from the

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How Much Ozone?

The average amount of ozone in a column through the atmosphere will form a layer 3-millimeters thick when subjected to ground level temperature and pressure. The amount of ozone in such a column is usually specified in thousandths of a centimeter. Therefore, a 3-mm amount of ozone in a column through the atmosphere is usually expressed as 300 milli-atmosphere-centimeter or 300 m-atm-cm.

A single m-atm-cm of ozone is known as a Dobson unit or DU after G. M. B. Dobson, who invented the spectrophotometer that is still used today to measure the total amount of ozone in the atmosphere. Thus 300 m-atm-cm of ozone is equivalent to 300 DU. A single DU corresponds to approximately 1 part per billion of ozone.

sun. Diffuse radiation is that scattered from clouds and molecules of air. Global is the sum of direct and diffuse UV radiation. Most natural materials reflect UV rather poorly. But snow is an excellent UV reflector; and so is water. In short, exposed parts of your body can receive a significant does of UV even when shaded from the direct sun.

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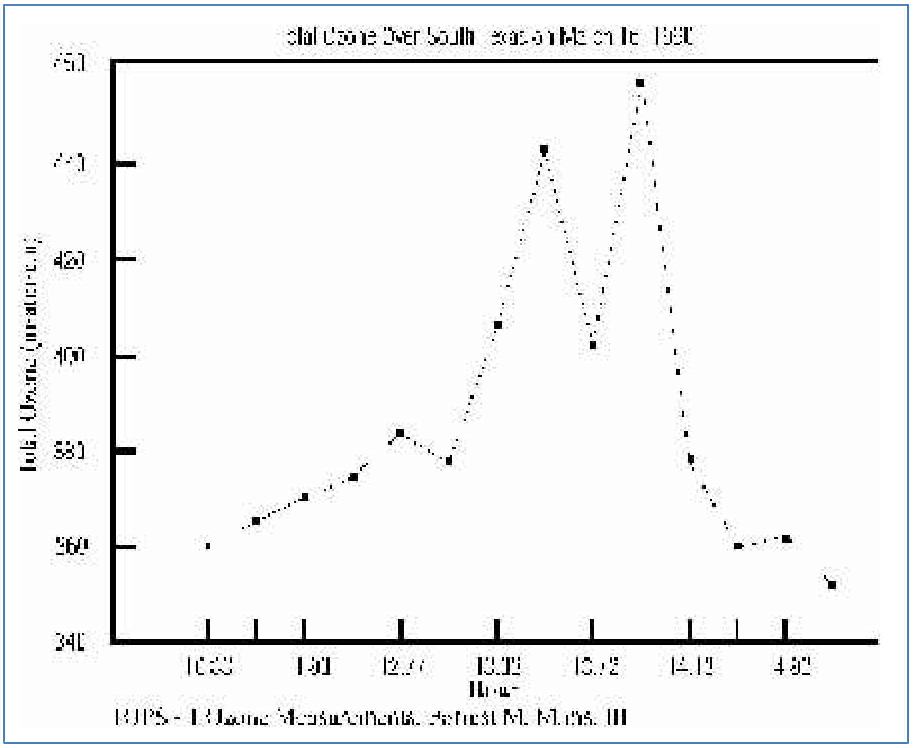

Figure 6 . Unusually high ozone measured by the author in Seguin, TX on March 16, 1990.

Ultraviolet Hazards

The energy of electromagnetic radiation is inversely related to its wavelength. In other words, radiation with short wavelengths–like x-rays–has much higher energy than radiation with longer wavelengths, such as visible light. For this reason, ultraviolet radiation is more energetic than visible light.

That's why the sun's UV-B radiation readily causes sunburn while UV-A and visible sunlight do not, even though much more UV-A and visible light reach the earth. (Of course, even visible sunlight will cause sunburn if it is concentrated with a lens or reflector.) The sun's UV-B can also damage the chromosomes in human skin cells–which can eventually lead to skin cancer. Excessive UV-B can also cause cataracts and alter the immune system.

Plants can be damaged by excessive UV-B. So can organisms that live at least part of their life cycle near the surfaces of lakes, rivers and oceans. More research is needed to better understand the nature of such damage and the amount and wavelengths of UV that are responsible.

Ultraviolet Benefits

The public has been frequently reminded about the dangers of UV-B exposure. It's important to realize, however, that solar UV also plays an essential role in human health.

Perhaps the most important contribution of solar UV is its ability to stimulate the production of vitamin D in the outer layers of the skin. This gives UV the ability to prevent and to cure rickets and to maintain a healthy skeleton. Both natural and artificial UV radiation are also used to treat psoriasis.

Measuring Ultraviolet Radiation

If you've ever retrieved a rolled up newspaper which has lain in the summer sun for a few hours, you know that newsprint darkens when exposed to solar UV. So does freshly cut or sanded pine and other woods. Colored construction paper and fabrics are bleached by solar UV.

A few years ago during a field trip to New Mexico, my son and I tacked a strip of freshly sanded pine atop the crate bolted in the back of our pickup that carried our instruments and supplies. We covered the wood with a strip of tape, several centimeters of which we removed each day. After 10 days on the UV-drenched highways of Texas and New Mexico, the strip of wood was divided into 10 segments, each slightly darker than the next.

Some chemicals will also change color when exposed to solar UV. But an electronic instrument is necessary to quantitatively measure the intensity of UV. The two principle kinds of UV sensors used with such instruments are phototubes and solid-state detectors. Specialized phototubes known as photomultipliers can be made exceptionally sensitive to UV. But they are expensive, fragile, and require a high operating voltage. Solid-state detectors are not as sensitive.

In addition, they are are cheaper, sturdier, and much easier to use.

An optical filter can be placed between a UV detector and the sun to enable the detector to respond only to specific regions of the UV spectrum. Alternatively, a prism or grating can be used to select specific wavelengths.

Various methods are used to measure direct, diffuse and global UV. Direct UV is easily measured by placing the detector inside a collimator tube that limits its field of view. Ideally, the field of view of the collimator should not exceed a few degrees.

Global UV is measured by placing a diffuser plate (such as ground silica or diffuse UV-transmitting plastic) over the detector and its filter.

Diffuse UV can be measured with a global detector by placing a small disk so that its shadow completely covers the detector. This blocks direct sunlight so that the detector signal is entirely from the diffuse sky. Subtracting the diffuse amount from the global value gives the direct UV.

Ozone vs. Sunlight

Ozone absorbs some of the sun's infrared radiation. It even weakly absorbs the wavelengths around 600 nm, which appear orange to the human eye. Its most important absorption, of course, occurs at UV wavelengths below around 340 nm. The absorption increases so rapidly below 320 nm that little or no measurable radiation below 295 nm reaches the surface at sea level.

As noted, it's important to understand that the scattering caused by dust and aerosols can cause ozone near the ground to absorb more UV than an equal amount of ozone in the stratosphere. This helps explain why some scientific studies have found a slight decrease in UV-B over the past decade, a time during which the amount of stratospheric ozone has decreased and the amount of tropospheric ozone has increased.

As noted, it's important to understand that the scattering caused by dust and aerosols can cause ozone near the ground to absorb more UV than an equal amount of ozone in the stratosphere.

Conclusion

Evaluating claims about the ozone layer requires basic knowledge not only about ozone and its effects on ultraviolet, but about the research methods that have been used to understand the ozone layer's dynamics. Hopefully, this article has provided some of that knowledge–and perhaps even sparked some interest in doing some independent investigating. If so, be sure to check out some of the resources mentioned on page 10 ("Readings about Ozone and Ultraviolet.") Also, be sure to read the other articles in this issue, on the ozone hole and on the health effects of UV.

BOOK ORDERS

Trashing the Planet

Dixy Lee Ray with Lou Guzzo
206 pages, paperback
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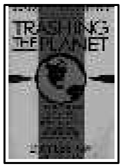

Dixy Lee Ray is the former governor of Washington, past chairman of the Atomic Energy Commission and a longtime member of the University of Washington zoology faculty. She is certainly qualified to explain how science can help us deal with acid rain, ozone depletion, nuclear waste and other environmental concerns. The *Wall Street Journal says,* "Her prescription is a sound one. More scientific inquiry and debate, more scientists speaking out on environmental issues, more measured discussion rather than rabble-rousing would be a welcome change from the current level of public debate."

Environmental Overkill

Dixy Lee Ray with Lou Guzzo
260 pages, hardback
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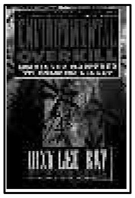

What ever happened to common sense? This book picks up where Dr. Ray's first book on the environment left off. New topics covered include food and population, endangered species, wetlands, forests and the problem of governing by regulation. Her insightful chapters on the Earth Summit in Rio and the views of Vice-President Al Gore make this book particularly timely. Easy to read, yet thoroughly documented.

To order see form on page 15

The Ozone Hole: Sorting Out the Facts

by Forrest M. Mims, III

In recent years, much attention has been given to the "ozone hole" over Antarctica. This phenomenon is observed each year in October during the Antarctic spring. After several weeks, the Antarctic vortex, a whirling weather system that encircles and isolates the South Pole during winter, breaks up and ozone levels rapidly rise.

In meterological terms, the Antarctic ozone hole is a significant ozone minimum and not a literal "hole" through the entire ozone layer. Nevertheless, for a brief time ozone levels within the hole can plummet to 100 DU. (Normal levels are about 300 DU.) At the same time, the ozone levels in a broad belt encircling the hole are the highest on earth.

Because various scientific studies have concluded that the ozone hole is caused in part by chlorine believed to come from manufactured chemicals–especially CFCs–some scientists, politicians, and government agencies have sounded an alarm about the prospect of severe ozone depletion leading to ozone holes elsewhere. In a widely publicized statement two years ago, then-Sen. Albert Gore raised the possiblity that an ozone hole might appear over Kennebunkport, Maine. Although a prominent NASA scientist discounted this possibility, other scientists held a press conference to express alarm about possible serious ozone depletion over the Arctic. Developments like these led to many scary reports in the media.

Fortunately, the Antarctic hole is a phenomenon preceded by the very cold temperatures and darkness found inside the winter Antarctic vortex, which is much stronger than the Arctic vortex.

Long before the ozone hole was identified in 1985, G.M.B. Dobson, inventor of the Dobson spectrophotometer, discovered something very different about Antarctic ozone. In a paper titled "Forty Years' Research on Atmospheric Ozone at Oxford: A History" (*Applied Optics*, March 1968), Dobson described an ozone monitoring program that began at Halley Bay, Antarctica, in 1956.

When the data began to arrive, "the values in September and October 1956 were about 150 [Dobson] units lower than expected. . . . In November the ozone values suddenly jumped up to those expected. . . . It was not until a year later, when the same type of annual variation was repeated, that we realized that the early results were indeed correct and that Halley Bay showed a most interesting difference from other parts of the world."

The ozone decline reported by Dobson was not nearly as severe as the one that characterizes the Antarctic ozone hole today. However, two scientists who reviewed old ozone records recently reported that the ozone amount in the spring of 1958 fell to only 110 DU at the French Antarctic Observatory at Dumont d'Urville.

In *Annales Geophysicae* (November, 1990), P. Rigaud and B. Leroy observed that in 1958, the Antarctic vortex, where the most significant ozone depletion occurs, was centered over Dumont d'Urville, on the opposite side of the South Pole from Halley Bay. They reported that the concentration of CFCs in the atmosphere in 1958 was much lower than it is today and concluded that natural phenomena, such as volcanic aerosols in the stratosphere, may also lead to ozone destruction.

Writing in a recent issue of *Science*, however NASA scientist Paul Newman has convincingly refuted Rigaud's and Leroy's ozone measurement methods. He pointed out that Rigaud and Leroy relied on photographic plates, an unreliable method for measuring stratospheric ozone.

Meanwhile, the chemistry and dynamics of the atmosphere inside the Antarctic and Arctic vortices remain the subjects of extensive research using various kinds of ground-based instruments, instrumented balloons, high-flying aircraft, and satellites.

Readings About Ozone and Ultraviolet

Over the past half century, thousands of scientific papers, articles and books have been published about ozone and solar UV.

If you want to study the history of the subject, the best paper by far is one by G.M.B. Dobson, inventor of the Dobson spectrophotometer, a ground-based instrument for measuring atmospheric ozone. The paper is titled "Forty Years' Research on Atmospheric Ozone at Oxford: A History" (*Applied Optics*, vol. 7, no. 3, March 1968, pages 387-405). Another outstanding paper, by one of Dobson's contemporaries, F.W. Paul Gotz, is "Ozone in the Atmosphere" (*Compendium of Meteorology*, American Meteorological Society, 1951, pages 275-291).

The most recent comprehensive scientific paper on ozone trends is "Measured Trends in Stratospheric Ozone" by Richard Stolarski, Rumen Bojkov and several others (*Science*, vol. 256, April 17, 1992, pages 342-349). This paper presents a detailed comparison of satellite and ground-based measurements and concludes there is "an apparent downward trend in the total column amount of ozone over mid-latitude areas of the Northern Hemisphere in all seasons."

For a summary of current knowledge of ultraviolet solar radiation reaching the earth's surface, see "Ultraviolet Sunlight Reaching the Earth's Surface: A Review of Recent Research," by John Frederick (Photochemistry and Photobiology, vol. 57, no. 1, pp. 175-178, 1993).

You can find many other articles about ozone and ultraviolet at any library. University libraries are best since they have many of the scientific journals that publish papers about ozone. Several books about ozone have also been published.

If you really want to dig into the scientific literature on utlraviolet and

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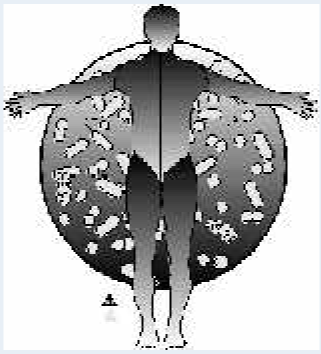
Ultraviolet and Your Health



by Mark Hartwig

Regardless of what you think about ozone depletion and CFCs, ultraviolet radiation (UVR) is very real. So are its effects. Even if we should see no long term increase in UVR, most places on earth receive more than enough to cause real problems if you often go outside without protecting yourself.

Sunburn

Perhaps the best-known consequences of excessive UVR exposure is erythema, or sunburn. Sunburns can be mild or severe. If you've had a severe sunburn, you'll not likely forget it. Such cases are marked by bright pink or even scarlet-colored skin, swelling, blistering, and exquisite pain. An extremely severe case may also be accompanied by nausea, fever or chills, and tachycardia (a racing heart beat). Because of water lost through the skin, sunburns can also lead to dehydration.

Actually, the painful symptoms of sunburn are caused more by the body's response to UVR skin damage than by the damage itself. Although no one really understands the whole process, UVR damage apparently triggers an increase of several chemical substances, including prostaglandins and histamines. Both substances contribute to inflammation. Whole body exposure can also lead to increased levels of serum interleukin-1 and interleukin-6, which could partly account for some of the symptoms associated with an extremely severe sunburn.

Sunburn is primarily caused by the UVR wavelengths between about 295 and 320 nanometers (nm). Wavelengths in this range are known as UV-B.[1] However, UVR between 320 and 400 nm–called UV-A–can also give you a burn. UV-A is less energetic than UV-B, but it can penetrate the top layers of skin, damaging the lowest level. It is also absorbed less efficiently by the atmosphere. Consequently, the ratio of UV-A to UV-B will increase as the sun gets lower in the sky, and its contribution to sunburn will be relatively high in the early morning and late afternoon.

Sun-Damaged Skin

Of course, sunburn is not the only effect of UVR. One effect of long-term exposure is sun-damaged skin–even in the absence of sunburn.

Much of what was once attributed to aging is now known to be caused by sun damage. Old age can bring about roughness, fine wrinkling, and looseness of the skin. Sun-exposed skin, however, is also marked by coarse wrinkling and elastosis, which gives the skin a pebbly, yellowed quality. Both wrinkling and elastosis are caused by damage to elastic fibers in the lowest level of skin, the dermis.

In addition to these effects, sun-exposed skin is also prone to irregular hyperpigmentation and depigmentation, and actinic keratoses–which are rough, red patches of precancerous skin cells.

Cataracts

Another long-term effect of UVR exposure is the formation of cataracts. A cataract is any change in the structure of the lens that leads to a loss of transparency.

Cataracts have been associated with many risk factors, including smoking, diabetes, steroids, episodes of severe dehydration, and–of course–UVR exposure.

As with skin damage, cataract formation is associated more with chronic exposure than acute exposure–which is not to say that acute exposure is recommended. Indeed, acute overexposure can lead to permanent or temporary blindness.

Snow Blindness

One particularly excruciating result of acute overexposure of the eyes is *keratoconjunctivitis*, or snow blindness. Snow blindness is essentially a sunburn on the surface of the eye (i.e. the cornea and conjunctiva).

Symptoms include redness of the eyes and a gritty feeling, which progresses to pain and an inability to tolerate any kind of light. The pain has been compared to rubbing sandpaper across one's eyes. Fortunately, snow blindness is usually only temporary.

Sun and snow is an ideal combination for getting snow blindness. Snow is an outstanding UVR reflector, and the combination of direct and reflected sunlight is a double whammy for unprotected eyes. Skiers should thus be careful to protect their eyes when they hit the slopes.

Surfers should also be careful. Reflected light from the water can have the same effect as reflected light from snow.

Skin Cancer

Three kinds of skin cancer have been associated with UVR exposure: basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma.

By far the most common form of skin cancer is BCC, which makes up 75 to 90 percent of all skin cancers. It is strongly linked with sun exposure, and is rarely found on skin surfaces not

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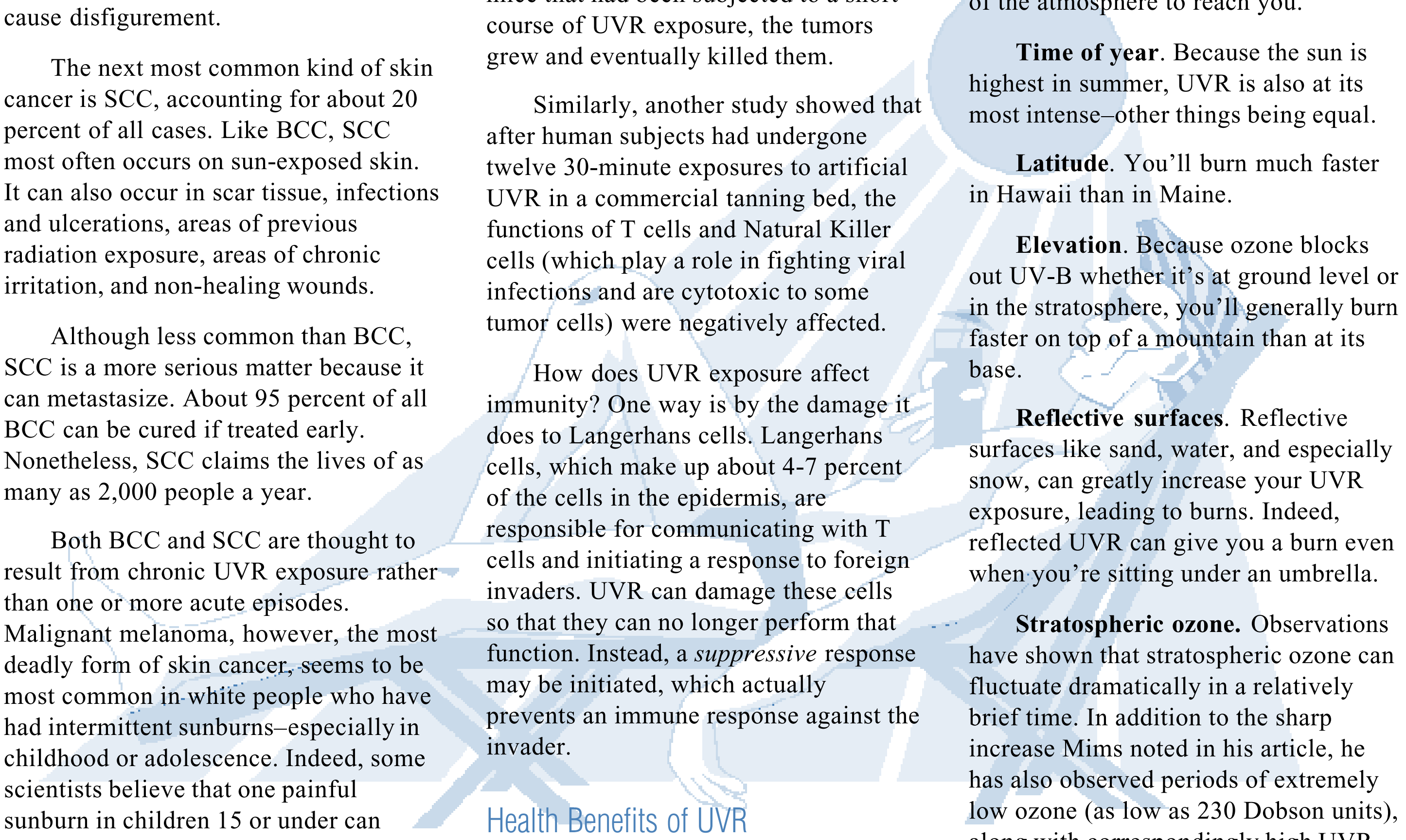

exposed to the sun. The only exceptions usually involve arsenic or radiation exposure, or complications from tattoos, scars, burns, or vaccinations.

Fortunately, BCC does not metastasize (except in some AIDS patients) and is slow growing. Nonetheless, if it is left untreated, it can damage or destroy underlying tissue and cause disfigurement.

The next most common kind of skin cancer is SCC, accounting for about 20 percent of all cases. Like BCC, SCC most often occurs on sun-exposed skin. It can also occur in scar tissue, infections and ulcerations, areas of previous radiation exposure, areas of chronic irritation, and non-healing wounds.

Although less common than BCC, SCC is a more serious matter because it can metastasize. About 95 percent of all BCC can be cured if treated early. Nonetheless, SCC claims the lives of as many as 2,000 people a year.

Both BCC and SCC are thought to result from chronic UVR exposure rather than one or more acute episodes. Malignant melanoma, however, the most deadly form of skin cancer, seems to be most common in white people who have had intermittent sunburns–especially in childhood or adolescence. Indeed, some scientists believe that one painful sunburn in children 15 or under can triple their odds of getting melanoma later on.

Also, indoor workers who vacation in the sun and get occasional burns are more likely to end up with melanoma than those who work in the sun.

Other possible factors include chemical carcinogens, viruses, and immune deficiencies.

Melanoma is easily cured if treated early. Once it spreads to the lymph nodes, the survival rate drops dramatically.

Immune System Deficiencies

Finally, excessive UVR can also produce immune system deficiencies. Indeed, the development of skin cancers may well be–at least in part–a result of immune system damage.

For example, in one study, skin cancers were induced in mice by exposing them to UVR. When these skin cancers were transplanted into normal, genetically identical mice, most were rejected by the new host's immune system. However, when transplanted to mice that had been subjected to a short course of UVR exposure, the tumors grew and eventually killed them.

Similarly, another study showed that after human subjects had undergone twelve 30-minute exposures to artificial UVR in a commercial tanning bed, the functions of T cells and Natural Killer cells (which play a role in fighting viral infections and are cytotoxic to some tumor cells) were negatively affected.

How does UVR exposure affect immunity? One way is by the damage it does to Langerhans cells. Langerhans cells, which make up about 4-7 percent of the cells in the epidermis, are responsible for communicating with T cells and initiating a response to foreign invaders. UVR can damage these cells so that they can no longer perform that function. Instead, a *suppressive* response may be initiated, which actually prevents an immune response against the invader.

Health Benefits of UVR

UVR is not all bad. For one thing, it assists in the production of vitamin D in skin cells. This vitamin D is absorbed by the body and then used in the up-take of calcium from the intestinal tract. This vitamin is essential for the growth and development of healthy bones. Fortunately, brief exposure to sunlight on a regular basis is enough to produce all the vitamin D most people need. The vitamin can also be obtained from dietary sources.

UVR is also useful for treating psoriasis and alopecia areata. But such treatment may also increase the risk of skin cancer, and should be undertaken only under the supervision of a knowledgeable physician.

Protection from the UVR

An important part of protecting yourself from excessive UVR exposure is to recognize that UVR intensity can vary as a result of many different factors, including:

Time of day. UVR is most intense when the sun is highest in the sky. That's because it has to pass through less of the atmosphere to reach you.

Time of year. Because the sun is highest in summer, UVR is also at its most intense–other things being equal.

Latitude. You'll burn much faster in Hawaii than in Maine.

Elevation. Because ozone blocks out UV-B whether it's at ground level or in the stratosphere, you'll generally burn faster on top of a mountain than at its base.

Reflective surfaces. Reflective surfaces like sand, water, and especially snow, can greatly increase your UVR exposure, leading to burns. Indeed, reflected UVR can give you a burn even when you're sitting under an umbrella.

Stratospheric ozone. Observations have shown that stratospheric ozone can fluctuate dramatically in a relatively brief time. In addition to the sharp increase Mims noted in his article, he has also observed periods of extremely low ozone (as low as 230 Dobson units), along with correspondingly high UVR levels. This occurred in June, 1993 and is occurring again this summer.

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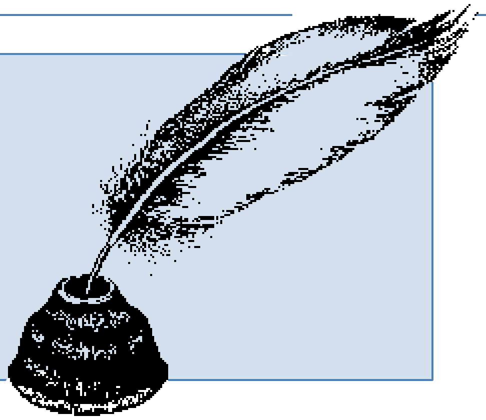
News & Notes



Research

Dimpled Baseball Bats

A technical instructor in the MIT Department of Aeronautics and Astronautics hopes to strike paydirt with his patented idea for a dimpled baseball bat. Jeffrey Di Tullio was working with the students in one of his lab courses on the problem of how to reduce drag on cylinders when he realized the applicability of the work to baseball bats. A conventional bat pushes air out of its way. A dimpled bat allows some air to flow around the contour of the bat. Less air to push means less drag, and that would mean higher bat speed, more momentum and better results for a hitter, he reasoned.

The aerodynamic principles that make his bat move through the air faster than a conventional bat are not new. However, almost all the published research on this subject involves the use of various types of surface roughness or bumps. Bumps on the surface of a baseball bat would not be acceptable for obvious reasons. So Di Tullio came up with another solution: dimples similar to those found on a golf ball.

Di Tullio made a die and pressed dimples into some wooden "brands" (bats without markings burned into them). He pressed rather than drilled the dimples so he wouldn't remove any material that would consequently make the bat lighter. With prototypes in hand, he moved into a wind tunnel at MIT to test his hypothesis that dimpled bats can be swung faster. It worked, and the development process was underway.

Environment

Eco-Friendly Pesticides

Two MIT chemists are developing non-traditional environmentally benign strategies for pest control. Most studies in the area of natural “communication” chemicals produced by plants and their pests have focused on luring pests into traps where they can be destroyed. The new research by Professor Rick Danheiser and Graduate Student Alexandre Huboux involves natural chemicals produced by plants starting their spring growth processes. In many cases, the same chemicals also “wake up” insect pests.

Danheiser and Huboux are designing a practical synthesis of glycinoclepin A, a natural substance that stimulates the soybean cyst nematode, a serious agricultural pest, to hatch. The substance would then be spread over fields in very small amounts during the winter, causing the nematodes to hatch into the cold and die.

The work is one of nine projects organized through the MIT Initiative in Environmental Leadership and funded by the V. Kann Rasmussen Foundation. The projects focus on the environmental impacts of chlorine. The Danheiser/Huboux work addresses a way to replace some of the chlorine-dependent pesticides currently on the market with natural alternatives.

Atmospheric Sciences

High-Latitude Ice Clouds May Be Visible in United States in Future

Noctilucent ice clouds, striking, silvery-blue apparitions that appear in the far northern latitudes each summer, are projected to creep south into the United States during the next century as a result of greenhouse gas increases in Earth’s middle atmosphere.

Professor Gary Thomas of the University of a Colorado at Boulder said new calculations indicate the high-altitude clouds will be five to 10 times brighter in the 21st century and will be visible for the first time in the continental U.S. Basking in the sunlight 50 miles above the Earth’s surface and into the middle atmosphere, said Thomas, who is affiliated with CU-Boulder’s Laboratory for Atmospheric and Space Physics. The methane then reacts with sunlight to form large quantities of water vapor that eventually freeze and circulate to the top of the mesosphere, facilitating noctilucent cloud formation.

The process is hastened by increasing amounts of rising carbon dioxide from Earth, he said. While CO$_2$ is thought to contribute to greenhouse warming in the lower atmosphere, the gas ironically cools the middle and upper atmosphere and creates conditions even more conducive to noctilucent cloud formation.

“In a sense it’s a double whammy,” he said. “This increase in both moisture and colder air is the most favorable condition for noctilucent cloud formation.”

A paper on the subject was presented by Thomas at the spring meeting of American Geophysical Union in Baltimore May 23 to May 27. Other authors of the paper included Eric

Jensen of NASA's Ames Research Center in Moffet Field, Calif., CU-Boulder doctoral student Robert Portmann and Rolando Garcia of Boulder's National Center for Atmospheric Research.

The noctilucent ice clouds, also known as polar mesopheric clouds, are the highest on Earth and occur in the coldest part of Earth's system, Thomas said. They have been visible for the past centrum during June and July from Canada, Alaska, Scotland, Finland, Sweden, Norway, Greenland and northern Russia. They also are visible at comparable latitudes in the Southern Hemisphere in the corresponding summer months of November and December.

Ice-core records indicate methane emissions have doubled in the past century and are likely to double again sometime in the 21st century, Thomas said. The model created by Portmann and his colleagues predicts a roughly 50 percent increase in water vapor in the mesosphere next century as a result of the increases.

Carbon dioxide records from NOAA's Mauna Loa Observatory in Hawaii since 1958 have triggered speculation that carbon dioxide emissions also will double sometime in the 21st century, said Thomas. The increase will probably cause the temperature in the upper mesosphere to decrease by about 18 degrees Fahrenheit.

"While they are a beautiful phenomenon, these clouds may be a message from Mother Nature that we are upsetting the natural equilibrium of the atmosphere," he said. "And it has taken us 100 years to decipher this message."

The clouds were first observed in 1885 after the eruption of Krakatoa near Java injected an estimated 100 million tons of water vapor into the normally dry upper atmosphere, he said. But they persisted each summer long after the effects of Krakatoa should have dissipated, causing Thomas and his colleagues to suggest in the late 1980s that the clouds may be a byproduct of the Industrial Revolution.

A puzzling increase has occurred in noctilucent cloud activity since the mid-1960s that is not explainable by methane and carbon dioxide increases, he said. He speculated CFC emissions could play some part in the increase, since ozone levels are one of the key components of the mesosphere's atmospheric chemistry.

Thomas and his colleagues also are investigating what, if any, effects the clouds may have on Earth's climate. It is possible the clouds could reflect sunlight back into space and cool Earth, or they could heat the planet by trapping greenhouse gases in the lower and middle atmospheres.

Data for the cloud observations were obtained from CU's Solar Mesosphere Explorer satellite in the 1980s and other orbiting spacecraft and rocket experiments, said Thomas. Two proposed unmanned NASA missions to explore the mesosphere involving CU-Boulder scientists—TIMED and TECHSAT—could provide additional data on the spectacular and troubling clouds.

Technology

Student Develops Less Expensive Way to Analyze and Match Paints

Most parents look at their child's education as a long-term investment. But Fred and Debbie Paschke are getting an immediate payback from their son, John, a senior electrical engineering student at the University of Illinois.

The Paschke's, who own a small hardware and lumber store in Mt. Carroll, Ill., couldn't justify spending many thousands of dollars to purchase the color-matching machines used by their competitors—larger hardware stores and paint retailers. The machines, which use elaborate programming and top-of-the-line computer hardware, allow stores to blend paint to match the exact color of paint chips brought in by customers.

John Paschke, aware of his parents' problem, decided to solve it. In an electrical engineering course in which students choose their own assignments, he developed a far cheaper color-match machine. The machine merely analyzes a point's red, green and blue components instead of checking every frequency in the color spectrum, a far more complex procedure.

"Red, green and blue are all our eyes are equipped to see," Paschke said. "That's the basis on which color television works: It mixes the primary colors to make pictures of every color."

Paschke's analyzer, which cost $120 in parts, shared a $1000 prize for creativity given during the U. of I.'s annual Engineering Open House in February.

The sample is placed below a small turntable that has three diodes attached to it. The analyzer shines light from three flashlight bulbs onto the sample. Each diode, which converts light into electricity, is covered by an inexpensive filter. One permits the passage only of green light, one permits blue to pass through, and the third permits the passage of red light. When a motor rotates the turntable, each diode absorbs one of the three colors as reflected from the sample. The greater the amount of light passing through each filter, the stronger the current put out by each diode. The current is converted to a voltage, digitized and represented electronically on a graph on a video monitor.

The zero point on the graph is set for black—the absence of color—and white—the combination of all color—represents the highest reading. To determine intermediate readings, a paint company's carded samples are fed into the analyzer. Color values are stored in the memory of a small circuit board, which costs $18.

In Paschke's latest version of the analyzer, he incorporated a new diode capable of transmitting all three primary colors. Thus, the analyzer doesn't need filters, turntable, motor and certain now-redundant circuitry. "The new model is cheaper and simpler," Paschke said. And it may be in place this summer in his parent's store.

Books • Tapes • Videos

Books

Virtual Reality *Howard Rheingold* *Simon and Schuster, 1988, 415 pages*	*Item# B011*	*12.00*
Euthanasia is Not the Answer: A Hospice Physician's View *David Cundiff* *Humana Press, 1992, 190 pages*	*Item# B012*	*17.95*
Working with Congress: A Practical Guide for Scientists and Engineers *William G. Wells Jr.* *AAAS, 1992, 130 pages*	*Item# B013*	*12.95*
Trashing the Planet: How Science Can Help Us *Dixy Lee Ray and Lou Guzzo* *Harper Collins, 1990, 206 pages*	*Item# B014*	*10.00*
Environmental Overkill: Whatever Happened to Common Sense *Dixy Lee Ray and Lou Guzzo* *Regnery Gateway, 1993, 260 pages*	*Item# B015*	*19.95*
Darwin on Trial Phillip Johnson *InterVarsity Press, 1993, 195 pages, paperback*	*Item# B001*	*9.95*
Evolution: A Theory in Crisis Michael Denton *1985,368 pages, hardback*	*Item# B003*	*19.95*
The Mystery of Life's Origins: Reassessing Current Theories Charles B. Thaxton, Walter L. Bradley, and Roger L. Olsen *1984, 228 pages, paperback*	*Item# B004*	*15.95*
Of Pandas and People Percival Davis and Dean H. Kenyon *Haughton, 1993,189 pages, hardback*	*Item# B005*	*19.95*
Teaching Science in a Climate of Controversy David Price, John L. Wiester, and Walter R. Hearn *American Scientific Affiliation, 1993,paperback*	*Item# B007*	*6.95*
Bones of Contention: Controversies in the Search for Human Origins *Roger Lewin* *Simon and Schuster, !988, 348 pages*	*Item# B009*	*10.95*
Invitation to Conflict: A Retrospective Look at the California Science Framework *Mark Hartwig and Paul Nelson* *ARN, 1992, 43 pages*	*Item# B010*	*4.95*

Audio Tapes

The Incredible World of Virtual Reality: Interview with Dennis Wagner and Kerby Anderson	*Item# C008*	*5.00*
What is Evolution and Why Does It Matter? Professor Phillip E. Johnson *Dec. 1991*	*Item# C001*	*5.00*
Darwin on Trial (2 tape set) Professor Phillip E. Johnson *Oct. 1992*	*Item# C002*	*10.00*
Phillip Johnson Interview by Joseph Busey, SCP KBLF Talkshow *Aug. 1992*	*Item# C003*	*5.00*
National Public Radio Debate; Phillip Johnson with Eugenie Scott NPR *Oct. 1993*	*Item# C004*	*5.00*
Phillip Johnson and Eugenie Scott (2 tape set) Wisconsin Public Radio *Aug. 1992*	*Item# C005*	*10.00*

Video Tapes

Darwinism on Trial: Phillip Johnson at UC Irvine *992, 1 hr. 45 min.*	*Item# V002*	*19.95*
Darwinism: Science or Philosophy: Phillip Johnson at UC Santa Barbara *1993, approx. 2 hrs.*	*Item# V003*	*19.95*
Darwinism: Science or Naturalistic Philosophy Debate at Stanford University with William Provine and Phillip Johnson *1994, approx. 2 hrs.*	*Item# V004*	*19.95*
Focus on Darwinism: An Interview with Phillip E. Johnson *1993, approx. 45 min.*	*Item# V001*	*19.95*
Focus on Darwinism: An Interview with Michael Denton *1993, 40 minutes*	*Item# V005*	*19.95*
Focus on Darwinism: An Interview with Dean Kenyon *1993, approx. 30 minutes*	*Item# V006*	*19.95*
Dean Kenyon: Focus on the Origin of Life *1993, approx. 30 minutes*	*Item# V007*	*19.95*

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Ultraviolet and Your Health

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So, what can you actually do to protect yourself from excessive UVR exposure?

1. If possible, avoid going outside during the midday hour, when solar UVR reaches its peak intensity. (Remember, midday is not necessarily at 12 p.m. It's when the sun is highest in the sky.)

2. If you do go outside, protect your eyes by wearing a hat and sunglasses. Studies have shown that using both of these is very effective in reducing UVR reaching the eyes–and in reducing risk of cataracts.

3. Protect your skin by wearing a sunscreen that provides both UV-A and UV-B protection, and has a sun protective factor (SPF) of 15 or more.[2] Sunscreen products are available with very high SPF ratings–45 and up. But the chemicals used in these products are more concentrated than they are at the lower ratings, and may cause skin irritation for some people.

You should also know that some chemicals can cause an allergic reaction–either by themselves or in combination with UVR. One such chemical is para-aminobenzoic acid (PABA), which was used in some of the earliest sunscreens developed. Because so many people are sensitive to PABA, its popularity and use has declined greatly in recent years.

Excessive exposure to UVR can have many undesirable consequences. But by taking a few sensible precautions, you can protect yourself and still have plenty of fun in the sun.

Notes

[1] Actually the UV-B spectral region includes wavelengths from 280 to 320 nm. But very little UVR reaches the ground at wavelengths shorter than 295 nm.

[2] SPF is a ratio that tells you how much energy it takes to produce a minimal sunburn through a sunscreen product compared to how much energy it takes to produce the same sunburn without the sunscreen. Thus, if you normally get a minimal burn in 20 minutes, it would take you 15 times as long, or five hours, to get one using a sunscreen with an SPF of 15. Of course, these numbers are generalizations, and will vary with several conditions, including skin type. Also, SPF refers only to UV-B. UV-A protection is rated by the percentage of UV-A that the sunscreen blocks.

Readings About Ozone and Ultraviolet

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ozone, William B. Grant of NASA has compiled a comprehensive bibliography. Specific topics include: solar radiation; changes in ozone distributions; factors that affect ozone distributions; absorption spectra of atmospheric molecular species; photolysis rates of atmospheric species absorbing in the UV-B region; aerosols; clouds; measurements of UV-B radiation; and the effects of UV-B radiation on man, plants, animals, and materials.

Grant has drawn on several sources for his bibliographic material: atmospheric science and general science journals; *Current Contents* and the *Science Citation Index*, published by the Institute for Scientific Information of Chicago, Illinois; environmental journals; *The Global Climate Change Digest*, Center for Environmental Information, 46 Prince Street, Rochester, NY 14607-1016, 716-271-0606; information supplied by researchers on UV-B; and general news sources. He also used bibliographies in published and unpublished compilations, and thanks Sasha Madronich, of the National Center for Atmospheric Research (NCAR) for the use of two of his bibliographies on UV-B radiation.

A copy of the bibliography (on a 3.5 inch disk) is available for the asking by writing to William B. Grant, 803 Marlbank Drive, Yorktown, VA, 23692-4353.

It's important to understand that some books and articles about ozone are not as objective as most scientific papers on the subject. The clash over ozone is especially well demonstrated by the cover story in the February 17, 1992, issue of *Time* and a response in the form of a cover story in the April 6, 1992, issue of *Insight*. If you read the first ("Vanishing Ozone") be sure to read the second ("Vanishing Facts").

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