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Assessment Statement - Effects
of Ozone Layer Modification

ASSESSMENT STATEMENT - EFFECTS OF OZONE LAYER MODIFICATION

Radiation at ultraviolet wavelengths between 280 nm and 320 nm is commonly referred to as ultraviolet-B (UV-B) radiation. Solar UV-B radiation which reaches the ground depends on many physical parameters such as the amount of atmospheric ozone, solar zenith angle, ground albedo, altitude and atmospheric scattering.

Monitoring of ground level UV-B radiation is just as important as monitoring ozone because UV-B radiation at the lower atmosphere directly affects several biological and photochemical reactions. UV-B radiation is measured by photodetectors which are sensitive at wavelengths weighted to approximate the eurythmically active spectrum. The intensity of this weighted UV-B flux falling on a horizontal surface is measured. Ground level UV-B radiation is measured by a ground based network. Satellites do not measure ground level UV-B from space.

A reduction in total column ozone would result in an increase in radiation reaching the troposphere and the earth's surface, particularly at the shorter wavelengths where radiation is more damaging to humans, plants, animals, and materials and exacerbates air pollutions. For example, a 1% depletion in total column ozone would increase DNA damaging UV-B radiation by 2%.

In this document, reference to UV-B indicates information derived solely from the evaluation of UV-B induced effects; reference to ozone or ozone depletion indicates information based on predictions of changes in UV-B flux resulting from changes in total column ozone.

There is a direct relationship between exposure to UV-B radiation and the incidence of non-melanoma skin cancer. A 1% decrease of total column ozone would lead to a 2% increase of carcinogenically effective UV-B irradiance. With unchanged exposure habits, this would result in an average increase of the incidence rates of basal cell carcinoma by about 4% and of squamous cell carcinomas by about 6%.

Non-melanoma skin cancers occur in people of all skin types, the incidence is highest in light-skinned people. Most non-melanoma skin cancers can be cured. Somewhat less than 1% result in death.

Melanoma, though less frequent, is a more serious form of skin malignancy. Between 25% and 40% of all melanoma cases result in death. The evidence supporting the relationship between malignant melanoma and sunlight is more circumstantial than the evidence that supports the relationship between sunlight and non-melanoma skin cancers. The evidence comes from a variety of studies, and is not accepted by a few scientists. Of the components of sunlight, UV-B is the most likely waveband for producing melanomas. In the United States, epidemiological studies indicate that a 1% ozone depletion could increase incidences of melanoma by about 2%, assuming the relationship between UV-B and melanoma is causal. Similar projections of increase in skin melanoma are not available from most countries.

It is generally accepted that exposure to UV-B is associated with accelerated skin aging, consequently total column ozone depletion is likely to accelerate this effect.

Recent research indicates that UV-B radiation alters several responses of the immunological system. The doses of UV-B radiation causing these immunological changes are much smaller than those which are associated with an increased incidence of tumors. Some experimental results indicate that infectious diseases with a cutaneous component could be exacerbated by the increased UV-B radiation associated with ozone depletion. Herpes and the tropical skin disease leishmaniasis are two such diseases for which some evidence exists. Some evidence supports the hypothesis that melanoma of the eye could be increased by sunlight and these might possibly be induced by UV-B radiation. Studies on animals and epidemiological data support the conclusion that UV-B radiation is one of the causes of cataracts. Epidemiological studies support the conclusion that a 1% total column ozone depletion would result in between 0.2% and 0.6% increase in cataract prevalence.

The relationship among ozone depletion, UV-B radiation, and biological effect varies temporally, spatially, and by biological process. In many cases there is a greater percentage change in biological response than the percentage change in total column ozone.

A 10% decrease in total column ozone would produce a level of biologically effective UV-B radiation in temperate latitudes equivalent to radiation levels currently found in the tropics.

Based on limited results from field and laboratory experiments:

- Increases in UV-B radiation reduce yield in certain agricultural crops, and alter competition among plants. Knowledge of biological mechanisms associated with increases in UV-B radiation has aided the interpretation of current field studies.
- Many soybean varieties are sensitive to increased UV-B radiation. One particular variety showed a yield loss of up to 25% following exposure to UV-B radiation simulating a 20% ozone reduction.
- Many plants, including some economically important crops such as soybean, cabbage and squash, are more susceptible to UV-B radiation than others. Differential UV sensitivity may be due to differences in adaptive mechanisms.
- UV-B radiation alters the reproductive capacity of some plants.
- UV-B radiation affects the quality of harvestable products.
- Reduced vigor in UV-B sensitive plants could render them more susceptible to pest or disease damage and thus result in reductions in crop yield.
- Increased UV-B radiation affects competition among plant species. In conjunction with other stresses, increased UV-B radiation also could alter ecosystems in ways not yet understood.

- The effectiveness of UV-B radiation can be greatly modified by other environmental factors, such as water and mineral stresses.

UV-B radiation damages larval stages of fish, shrimp and crab, as well as other zooplankton and plants essential to marine food webs, including those comprising commercial fisheries.

Solar UV-B radiation has important ecological effects. Sunlight-exposed organisms sacrifice potential resources to avoid UV-B radiation damage. Thus, even small increases in UV-B radiation would be likely to further injure the marine species currently under the most stress.

Current ambient levels of UV-B radiation reduce the survival of many aquatic microorganisms by decreasing their reproductive capacity and restricting their ability to move into favourable environments. Therefore, increased levels of exposure would further reduce the population size.

A decrease in total column ozone could shorten the season in which zooplankton can feed near the surface causing a mismatch in timing between food availability and food requirements.

Studies show an 8% loss of the larval anchovy population for a 9% total ozone column reduction.

Exposure of a marine community to UV-B radiation stress results in a decrease of species diversity, and therefore in a reduction of ecosystem resilience and flexibility.

The use of plastics/rubber materials in building and in other outdoor applications shows a consistent increase worldwide. This is true of developing countries as well, where plastics represent an inexpensive substitute for conventional materials. Ultraviolet radiation (particularly UV-B), in general, leads to changes in physical and mechanical properties of plastics, often severely shortening the service-life outdoors.

The extent of such degradation depends on the spectral sensitivity, dose-response relationship and the amount of light-stabilizer (chemical additives used to protect the material from light-induced degradation) incorporated into the polymer formulation.

The increased degradation of a given type of plastic material as a result of incremental UV-B radiation increase cannot be reliably estimated at the present time. This is due to the lack of relevant experimental data on the plastics compositions commonly used in outdoor applications. Preliminary estimates, however, show the degradation of materials involved is likely to be substantial.

In the event of UV radiation level increase, the plastics/rubber industry may act in several ways to mitigate the damage. Increasing the levels of currently used conventional light stabilizers is likely to be an initial strategy. A preliminary case study of rigid PVC plastics show that the conventional stabilizer technology can be used only to a limited extent under such conditions. Such a strategy will involve increased production costs and is likely to diminish in effectiveness with increasing UV light-levels.

As UV-B radiation increase due to total column ozone depletion will be felt to varying extents in different geographical regions, the strategies adopted to increase the protection of outdoor plastics may differ from region to region.

Most trace gases which have been so far identified as having an impact on ozone chemistry, also exhibit, greenhouse properties. The observed increasing concentrations in such gases is expected to lead to substantial increases in global mean surface temperature during the next century and beyond. A major effect of such a warming would be a rise in the mean sea level.

Redistribution of total column ozone could also contribute to a global warming. Steps to control any one of the trace gases capable of interacting with ozone could reduce, but not eliminate, a rise in sea level. The major contribution by the other greenhouse gases would remain.

The initial causes of sea level rise should be thermal expansion and alpine ice melting. Prediction of sea level rise is uncertain, but a warming in the range of 1.5°C to 4.5°C is estimated to lead to a rise of between 20 cm and 140 cm. Sea level rise will inundate and erode coastal land, increase flooding and produce saltwater intrusion into freshwater areas. Wetlands and river deltas will be adversely affected. Regions of the world that have low topographic relief, are storm-prone and/or have concentrations of human populations and economic activity are especially vulnerable to sea level rise. Typically, coastal areas tend to have high concentrations of populations and economic activity.

Preliminary studies suggest that adverse consequences could be substantially reduced by anticipatory coastal planning.

In a recently published modeling study and in one experimental study it was suggested that the decrease in total column ozone will influence the photochemistry of urban pollutants and could cause increases of ground level ozone. As a result, and also because peak concentrations would tend to occur closer to the emission sources (where population densities are also typically large), more people could be exposed to excessive ozone concentrations.

The study also predicted that, under certain conditions, hydrogen peroxide formation is extremely sensitive to increased UV-B radiation. Some acidification processes are known to be influenced by the hydrogen peroxide. More investigations of these potential effects are necessary.

Global warming can be expected to alter urban photochemical effects of increased total column ozone. One study has shown that most of the expected chemical enhancement stems from a thermal shift in the balance between urban ozone and peroxyacetyl nitrate (PAN), a cooxidant formed in urban atmospheres along with urban ozone.
