Q2 Why do we care about atmospheric ozone?

Ozone in the stratosphere absorbs a large part of the Sun's biologically harmful ultraviolet radiation. Stratospheric ozone is considered "good" ozone because of this beneficial role. In contrast, ozone formed at Earth's surface in excess of natural amounts is considered "bad" ozone because this gas is harmful to humans, plants, and animals.

Ozone in the stratosphere *(Good ozone)*. Stratospheric ozone is considered good for humans and other life forms because ozone absorbs ultraviolet (UV) radiation from the Sun (see **Figure Q2-1**). The Sun emits UV radiation that scientists categorize into three wavelength ranges: UV-C (100 to 280 nanometer (nm) wavelengths); UV-B (280 to 315 nm), and UV-A (315 to 400 nm). The energy of solar UV radiation, which cannot be seen by the human eye, is higher at shorter wavelengths. Exposure to high energy UV-C radiation is particularly dangerous to all life forms. Fortunately, UV-C radiation is entirely absorbed within the ozone layer. Most UV-B radiation emitted by the Sun is absorbed by the ozone layer; the rest reaches Earth's surface. In humans, increased exposure to UV-B radiation raises the risks of skin cancer and cataracts, and suppresses the immune system. Exposure to UV-B radiation before adulthood and cumulative exposure are both important health risk factors. Excessive UV-B exposure also can damage terrestrial plant life, including agricultural crops, single-celled organisms, and aquatic ecosystems. Low energy UV radiation, UV-A, which is not absorbed significantly by the ozone layer, causes premature aging of the skin.

Protecting stratospheric ozone. In the mid-1970s, it was discovered that gases containing chlorine and bromine atoms released by human activities could cause stratospheric ozone depletion (see Q5 and Q6). These gases, referred to as halogen source gases, and also as ozone-depleting substances (ODSs), chemically release their chlorine and bromine atoms after they reach the stratosphere.

UV Protection by the Stratospheric Ozone Layer

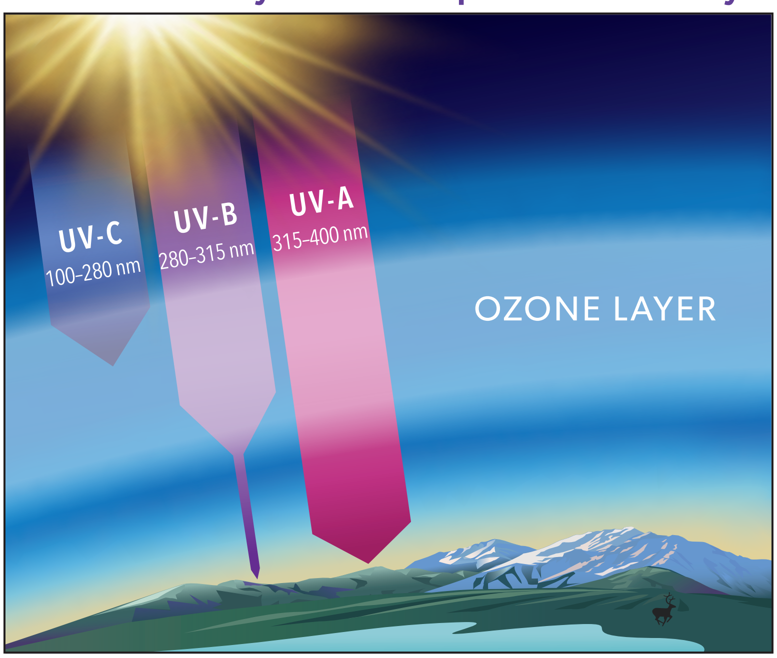

Figure Q2-1. UV protection by the ozone layer. The ozone layer is located in the stratosphere and surrounds the entire Earth. The Sun emits ultraviolet (UV) radiation that reaches the top of the ozone layer, which scientists classify according to wavelength. Solar UV-C radiation (wavelength range 100 to 280 nanometer (nm)) is extremely damaging to humans and other life forms; UV-C radiation is entirely absorbed within the ozone layer. Solar UV-B radiation (280 to 315 nm) is only partially absorbed and, as a result, humans and other life forms are exposed to some UV-B radiation. Excessive exposure to UV-B radiation increases the risks of skin cancer, cataracts, and a suppressed immune system for humans and also damages terrestrial plant life, single-cell organisms, as well as aquatic ecosystems. UV-A (315 to 400 nm), visible light, and other wavelengths of solar radiation are only weakly absorbed by the ozone layer. Exposure to UV-A is associated with premature aging of the skin and some skin cancers. Depletion of the ozone layer primarily increases the amount of UV-B radiation that reaches the surface (Q16). Avoiding ozone depletion that would increase human exposure to UV-B radiation is a principal objective of the Montreal Protocol.

(The unit "nanometer" (nm) is a common measure of the wavelength of light; 1 nm equals one billionth of a meter ($=10^{-9}$ m).)

Ozone depletion increases surface UV-B radiation above naturally occurring amounts. International efforts have been successful in protecting the ozone layer through controls on the production and consumption of ODSs (see Q14 and Q15).

Ozone in the troposphere *(Bad ozone)*. Ozone near Earth's surface in excess of natural amounts is considered bad ozone (see Figure Q1-2). Surface ozone in excess of natural levels is formed by reactions involving air pollutants emitted from human activities, such as nitrogen oxides (NO_x), carbon monoxide (CO), and various hydrocarbons (gases containing hydrogen, carbon, and often oxygen). Exposure to ozone at concentrations above natural levels is harmful to humans, plants, and other living systems because ozone reacts strongly to destroy or alter molecules that constitute biological tissue. Enhanced surface ozone caused by air pollution reduces crop yields and forest growth. In humans, exposure to high levels of ozone can reduce lung capacity; cause chest pains, throat irritation, and coughing; and worsen pre-existing health conditions related to the heart and lungs. In addition, increases in tropospheric ozone lead to a warming of Earth's surface because ozone is a greenhouse gas (GHG) (see Q17). The negative effects of excess tropospheric ozone contrast sharply with the protection from harmful UV radiation afforded by preserving the natural abundance of stratospheric ozone.

Reducing tropospheric ozone. Limiting the emission of certain common pollutants reduces the production of excess ozone near Earth's surface, where ozone can affect humans, plants, and animals. Major sources of pollutants include large cities, where fossil fuel consumption for transportation, heating, and industrial activities is concentrated, power plants that rely on coal, oil, or natural gas, as well as deforestation, wildfires, and the burning of savannah for agriculture. Many programs around the globe have been successful in reducing or limiting the emission of pollutants that cause production of excess ozone near Earth's surface.

Natural ozone. In the absence of human activities, ozone would still be present near Earth's surface and throughout the troposphere and stratosphere because ozone is a natural component of the clean atmosphere. Natural emissions from the biosphere, mainly from trees, participate in chemical reactions that produce ozone. Atmospheric ozone plays important ecological roles beyond absorbing UV radiation. For example, ozone initiates the chemical removal of many pollutants as well as some GHGs, such as methane (CH_4). In addition, the absorption by ozone of solar UV radiation as well as visible and infrared radiation is a natural source of heat in the stratosphere, causing temperatures to increase with altitude. Stratospheric temperatures affect the balance of ozone production and destruction processes (see Q1) and air motions that redistribute ozone throughout the stratosphere (see Q3).