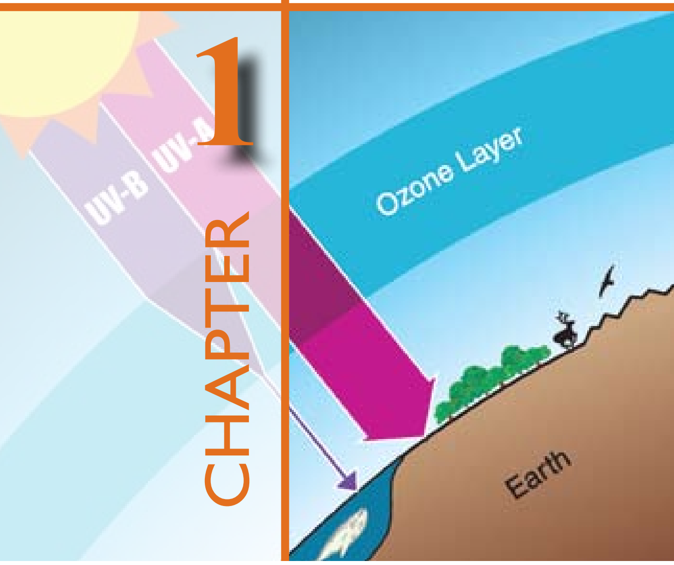


Introduction

Convening Lead Authors: A.R. Ravishankara, NOAA; Michael J. Kurylo, NASA; Anne-Marie Schmoltner, NSF

Ozone (O_3) is the triatomic form of oxygen. It is a key atmospheric trace gas that is present everywhere in the atmosphere and is most abundant in the stratosphere. The abundance of ozone in the stratosphere is largest in the region that is roughly between 15 and 35 kilometers (km) height above the Earth's surface, which is referred to as the stratospheric ozone layer. This stratospheric ozone layer (Box 1.1) plays many important roles in the Earth system:

- It protects the lower part of the atmosphere (the troposphere) and the Earth's surface from damaging, or "harsh" ultraviolet[1] (UV) radiation from the sun;
- It influences the chemical composition of the lower atmosphere by altering the amount and type (wavelength distribution) of solar radiation passing through it;
- It changes the temperature structure of the stratosphere and thus influences atmospheric transport and mixing; and
- It contributes ozone to the upper troposphere, where ozone is an important greenhouse gas.

Because of many of the above contributions, ozone in the stratosphere and its changes also play a significant role in the Earth's climate system; changes in the ozone layer are influenced by climate change and also contribute to climate change. Appendix A of this Product contains background information and answers to some of the most frequently asked questions about the stratospheric ozone layer (Fahey, 2007).

The focus of this Product is on key issues related to: (1) the stratospheric ozone layer, including its changes in the past, its current abundances, and expected levels in the future; (2) emissions of ozone-depleting substances (ODSs) and their influences on the ozone layer and climate; and (3) the changes in the ground-level UV radiation associated with stratospheric ozone changes.

The potential for human-produced chemicals, such as chlorofluorocarbons (CFCs), to deplete the stratospheric ozone layer has received a great deal of attention since the early 1970s.

[1] 'Harsh' UV radiation indicates the higher energy portion of the UV spectrum.

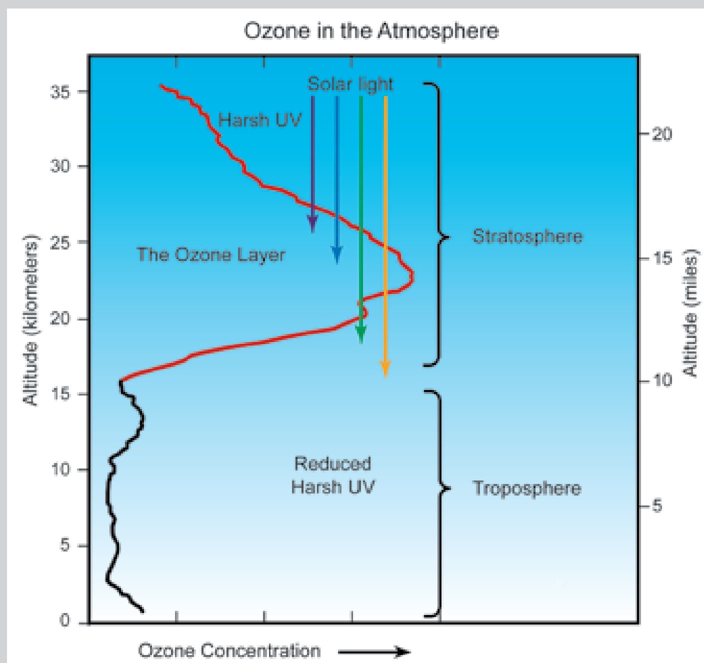
The nations of the world agreed to protect the ozone layer through the 1985 Vienna Convention. That same year the ozone hole in Antarctica was discovered.

The chemical processes that lead to the formation of ozone, as well as those that remove or destroy it, are distinctly different in the stratosphere from those in the troposphere (Box 1.2). The ever-present balance in the stratosphere between production, removal, and transport determines the abundance of ozone in any given part of the ozone layer. The majority of the removal processes in the stratosphere involve catalytic cycles in which ozone-destroying chemicals are re-formed after destroying ozone. This catalytic capability is a key reason why very small amounts of ozone-destroying chemicals introduced into the atmosphere can vastly influence the ozone layer (Box 1.2).

The potential for human-produced chemicals, such as chlorofluorocarbons (CFCs), to deplete the stratospheric ozone layer has received a great deal of attention since the early 1970s. The depletion by chlorine released from CFCs in the stratosphere was expected to be catalytic in nature, meaning that small amounts of CFCs could destroy vast amounts of ozone. The ozone depletion was predicted to lead to changes in UV radiation at the Earth's surface, with potentially major environmental consequences. The anticipated effects of increased UV radiation included: increased incidence of skin cancer and cataracts in humans; detrimental effects on ecosystems including the aquatic system; and harmful effects on materials, such as rubber and plastics. These potential effects were debated and the nations of the world agreed to protect the ozone layer through the 1985 Vienna Convention. Then the ozone hole in Antarctica was discovered in 1985. Investigation of the causes of this annually recurring

BOX 1.1: The Stratospheric Ozone Layer and Its Role in the Atmosphere

About 90% of the atmospheric ozone resides in the stratosphere, in a region between roughly 15 and 35 km above the Earth's surface, as indicated by the red line in Box Figure 1.1. This region is referred to as the stratospheric ozone layer. The remainder of the atmospheric ozone resides in the troposphere, the lower layer of the atmosphere. Stratospheric ozone is formed and destroyed by chemical reactions, as shown in Box 1.2. Of particular note are the need for higher-energy UV radiation for the formation of ozone and the catalytic nature of the ozone removal processes. The ozone layer in turn shields the lower part of the atmosphere and the surface from damaging UV radiation because ozone itself absorbs UV radiation. Depletion of the ozone layer allows more UVB radiation (wavelength 280 to 315 nanometers) to reach the Earth's surface. This radiation is harmful to humans and many other biological systems and causes damage to materials. The ozone in the lower atmosphere, the troposphere, is formed by methods different from those in the stratosphere, as shown in Box 1.2. Further, the contribution of this lower atmospheric ozone to the total in the atmosphere is small, of the order of a few percent in the Southern Hemisphere to about 10% in the Northern Hemisphere. The ozone in the lower atmosphere is harmful because, in direct contact, ozone is toxic to biological systems and can deteriorate many materials. It can cause respiratory and other health problems for humans. In addition, ozone and its changes in both the stratosphere and the lower atmosphere are important greenhouse gases and thus their changes influence climate. See Appendix A of this Synthesis and Assessment Product for further background information about ozone.



Box Figure 1.1 This figure shows the distribution of ozone in the atmosphere (adapted from Fahey, 2007; see Appendix A of this Report).