CHAPTER 7

Ozone and Stratospheric Chemistry

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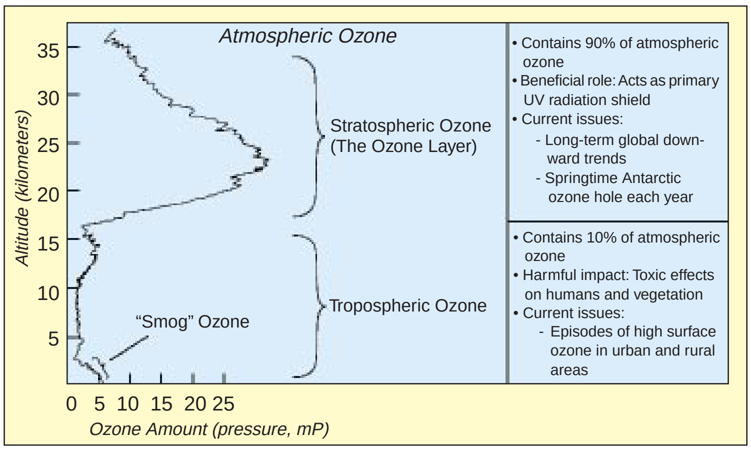
Chapter 7 Contents

7.1 Stratospheric ozone - background

7.1.1 Why is understanding stratospheric ozone important?

Ozone is one of the most important trace species in the atmosphere. Ozone plays two critical roles: it removes most of the biologically harmful ultraviolet light before the light reaches the surface, and it plays an essential role in setting up the temperature structure and therefore the radiative heating/cooling balance in the atmosphere, especially the stratosphere (the region between about 10 and 60 km).

FIGURE 7.1



The distribution of atmospheric ozone in partial pressure as a function of altitude.

7.1.1.1 Location of the ozone layer and climatology

Ozone is mainly found in two regions of the atmosphere. Most of the ozone can be found in a layer between 10 and 60 km above the Earth's surface (Figure 7.1). This ozone region located in the stratosphere is known as the "ozone layer." Some ozone can also be found in the lower atmosphere (below 10 km) in the region known as the troposphere. Although chemically identical to stratospheric ozone, tropospheric ozone is quite distinct and geophysically different from stratospheric ozone, and the science issues concerning tropospheric ozone are discussed in Chapter 4.

7.1.1.2 Ozone and UV—biological threat

Ozone is produced by the photolysis of molecular oxygen, O_2. The oxygen atom, O, produced by this photolysis recombines with O_2 to form ozone, O_3. Ozone formation primarily occurs in the tropical upper stratosphere, where it is transported poleward and downward by the large-scale Brewer-Dobson circulation. The global distribution of total ozone is shown in Figure 7.2 (pg. 312). This figure represents the 13-year average of the total ozone measurements taken by the Nimbus-7 Total Ozone Mapping Spectrometer (TOMS) instrument.

The formation of ozone by the photolysis of molecular oxygen removes most of the incident sunlight with wavelengths shorter than 200 nm. The wavelengths between 200 and 310 nm are removed by the photolysis of ozone itself. This photolysis of ozone in the stratosphere is the process by which most of the biologically damaging ultraviolet sunlight (UV-B) is filtered out.

As this filtering process occurs, the stratosphere is heated. This heating is responsible for the temperature structure of the stratosphere, where the temperature increases as the altitude increases. Without this filtering, larger amounts of UV-B would reach the surface. Numerous studies have shown that excessive exposure to UV-B is harmful to plants, animals, and humans (WMO 1992).

7.1.1.3 Ozone and climate change

If ozone in the stratosphere were to be removed, the stratosphere would cool. How a cooler stratosphere affects radiative balance in the rest of the atmosphere has been the subject of many detailed studies. These studies have been reanalyzed and integrated into the latest Intergovernmental Panel on Climate Change (IPCC) report, "Climate Change 1994: Radiative Forcing of Climate Change" (1995). The conclusion of that report is that stratospheric ozone loss leads to a "small but non-negligible offset to the total greenhouse forcing from CO_2, N_2O, CH_4, CFCs...." It is ironic that the size of the negative radiative forcing from ozone loss is nearly equal to the positive radiative forcing from chlorofluorocarbons (CFCs), the source of the stratospheric ozone loss. The size of the radiative forcing due to stratospheric ozone loss has also been shown to be very sensitive to the profile shape assumed for that loss.