Q13 How large is the depletion of the global ozone layer?

Depletion of the global ozone layer began gradually in the 1980s and reached a maximum of about 5% in the early 1990s. The depletion has lessened since then and now is about 3.5% averaged over the globe. The average depletion exceeds the natural year-to-year variations of global total ozone. The ozone loss is very small near the equator and increases with latitude toward the poles. The larger polar depletion is attributed to the late winter/early spring ozone destruction that occurs there each year.

Global total ozone has decreased beginning in the 1980s (see Figure Q13-1). The decreases have occurred in the stratospheric ozone layer where most ozone resides (see Figure Q1-2). In the early 1990s, the depletion of global total ozone reached a maximum of about 5% below the 1964–1980 average. The depletion has lessened since then and now averages about 3.5% for 2006–2009. The observations shown in Figure Q13-1 have been smoothed to remove regular ozone changes that are due to natural seasonal and solar effects (see Q14). The depleted amounts are larger than the remaining natural variations in global total ozone amounts.

The observed global ozone depletion in the last three decades is attributable to increases in reactive halogen gases in the stratosphere. The lowest global total ozone values since 1980 have occurred in the years following the eruption of Mt. Pinatubo in 1991, which temporarily increased the number of sulfuric acid-containing particles throughout the stratosphere. These particles significantly increased the effectiveness of reactive halogen gases in destroying ozone (see Q14) and, thereby, increased global ozone depletion by 1–2% for several years following the eruption.

Polar regions. Observed total ozone depletion varies significantly with latitude on the globe (see Figure Q13-1). The largest reductions have occurred at high southern latitudes as a result of the severe ozone loss over Antarctica each late winter/early spring period. The next largest losses are observed in the high latitudes of the Northern Hemisphere, caused in part by winter losses over the Arctic. Although the depletion in polar regions is larger than at lower latitudes, the influence of polar regions on global ozone is limited by their small geographical area. Latitudes above 60° account for only about 13% of Earth's surface.

Midlatitude regions. Ozone depletion is also observed at the midlatitudes spanning the region between equatorial and polar latitudes. In comparison with the 1964–1980 averages, total ozone averaged for 2005–2009 is about 3.5% lower in northern midlatitudes (35°N–60°N) and about 6% lower at southern midlatitudes (35°S–60°S). Midlatitude depletion has two contributing factors. First, ozone-depleted air over both polar regions is dispersed away from the poles during and after each winter/spring period, thereby reducing average ozone at nonpolar latitudes. Second, chemical destruction occurring at midlatitudes contributes to observed depletion in these regions. This contribution is much smaller than in polar regions because the amounts of reactive halogen gases are lower and a seasonal increase of the most reactive halogen gases, such as the increase in ClO in Antarctic late winter (see Figure Q8-3), does not occur in midlatitude regions.

Tropical region. There has been little or no depletion of total ozone in the tropics (20°N–20°S latitude). In this region of the lower stratosphere, air has only recently (less than 18 months) been transported from the lower atmosphere (troposphere). As a result, the conversion of ozone-depleting substances (ODSs) to reactive halogen gases is very small. With so little reactive halogen amounts, total ozone depletion in this region is also very small. In addition, ozone production is high in the tropical stratosphere because average solar ultraviolet radiation is highest in the tropics. In contrast, stratospheric air in polar regions has been in the stratosphere for an average of 4 to 7 years, allowing time for significant conversion of ODSs to reactive halogen gases. The systematic differences in the age of stratospheric air are a well-understood consequence of the large-scale atmospheric transport: air enters the stratosphere in the tropics, moves poleward into both hemispheres, and then descends and ultimately returns to the lower atmosphere.

Recovery of global ozone. Global ozone is no longer declining as it was in the 1980s and early 1990s because ODSs are no longer increasing in the atmosphere (see Q16). During recovery from ODSs, global total ozone is expected to reach 1980 and earlier values in the coming decades. The recovery process depends on the slow removal of ODSs from

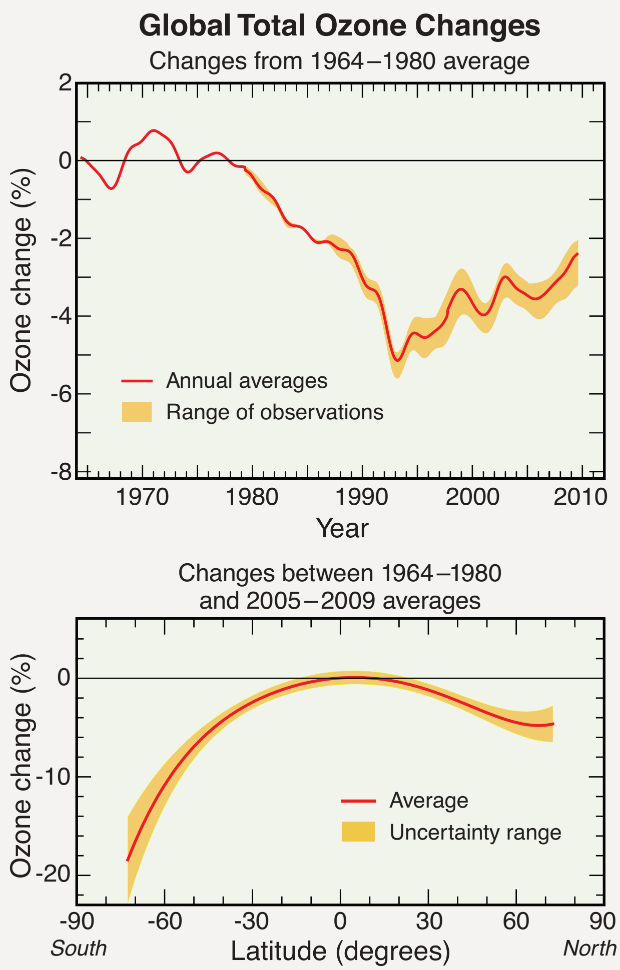

Figure Q13-1. Global total ozone changes. Satellite observations show depletion of global total ozone beginning in the 1980s. The top panel compares annual averages of global ozone with the average from the period 1964 to 1980 before the ozone hole appeared. Seasonal and solar effects have been removed from the observational data set. On average, global ozone decreased each year between 1980 and 1990. The depletion worsened for a few years after 1991 due to the effect of volcanic aerosol from the Mt. Pinatubo eruption. Average global ozone for 2005–2009 is about 3.5% below the 1964-to-1980 average. The bottom panel shows how the 2005–2009 depletion varies with latitude over the globe. The largest decreases have occurred at high latitudes in both hemispheres because of the large winter/spring depletion in polar regions. The losses in the Southern Hemisphere are greater than those in the Northern Hemisphere because of the Antarctic ozone hole. Long-term changes in the tropics are much smaller because reactive halogen gases are less abundant in the tropical lower stratosphere than at mid or high latitudes and ozone production rates are greater.

the stratosphere following emission reductions. Future changes in climate parameters will also influence ozone. The global ozone increases observed in the last 20 years cannot be attributed solely to reductions in ODSs that began in the 1990s, because global ozone also responded strongly to the Mt. Pinatubo eruption. The projections of long-term changes in total ozone for different regions of the globe are described in Q20.