CHANGES IN BIOLOGICALLY-ACTIVE ULTRAVIOLET RADIATION REACHING THE EARTH'S SURFACE

Abstract

The Montreal Protocol is working. Concentrations of major ozone-depleting substances in the atmosphere are now decreasing, and the decline in total column amounts seen in the 1980s and 1990s at mid-latitudes has not continued. In polar regions, there is much greater natural variability. Each spring, large ozone holes continue to occur in Antarctica and less severe regions of depleted ozone continue to occur in the Arctic. There is evidence that some of these changes are driven by changes in atmospheric circulation rather than being solely attributable to reductions in ozone-depleting substances, which may indicate a linkage to climate change. Global ozone is still lower than in the 1970s and a return to that state is not expected for several decades. As changes in ozone impinge directly on UV radiation, elevated UV radiation due to reduced ozone is expected to continue over that period. Long-term changes in UV-B due to ozone depletion are difficult to verify through direct measurement, but there is strong evidence that UV-B irradiance increased over the period of ozone depletion. At unpolluted sites in the southern hemisphere, there is some evidence that UV-B irradiance has diminished since the late 1990s. The availability and temporal extent of UV data have improved, and we are now able to evaluate the changes in recent times compared with those estimated since the late 1920s, when ozone measurements first became available. The increases in UV-B irradiance over the latter part of the 20^{th} century have been larger than the natural variability. There is increased evidence that aerosols have a larger effect on surface UV-B radiation than previously thought. At some sites in the Northern Hemisphere, UV-B irradiance may continue to increase because of continuing reductions in aerosol extinctions since the 1990s. Interactions between ozone depletion and climate change are complex and can be mediated through changes in chemistry, radiation, and atmospheric circulation patterns. The changes can be in both directions: ozone changes can affect climate, and climate change can affect ozone. The observational evidence suggests that stratospheric ozone (and therefore UV-B) has responded relatively quickly to changes in ozone-depleting

substances, implying that climate interactions have not delayed this process. Model calculations predict that at mid-latitudes a return of ozone to pre-1980 levels is expected by the mid 21st century. However, it may take a decade or two longer in polar regions. Climate change can also affect UV radiation through changes in cloudiness and albedo, without involving ozone and since temperature changes over the 21st century are likely to be about 5 times greater than in the past century. This is likely to have significant effects on future cloud, aerosol and surface reflectivity. Consequently, unless strong mitigation measures are undertaken with respect to climate change, profound effects on the biosphere and on the solar UV radiation received at the Earth's surface can be anticipated. The future remains uncertain. Ozone is expected to increase slowly over the decades ahead, but it is not known whether ozone will return to higher levels, or lower levels, than those present prior to the onset of ozone depletion in the 1970s. There is even greater uncertainty about future UV radiation, since it will be additionally influenced by changes in aerosols and clouds.