

Report on the Environment

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Ozone-Depleting Substances Concentrations

Ozone, a gas present throughout the Earth's atmosphere, is a pollutant at the Earth's surface but forms a protective layer in the stratosphere, helping shield the Earth from the sun's ultraviolet (UV) radiation. Exposure to UV radiation is associated with skin cancer, cataracts, and other human health and ecological problems (U.S. EPA, 2006).

Starting in the late 1970s, stratospheric ozone levels were observed to be declining due to worldwide releases of various human-produced chemicals referred to as ozone-depleting substances (ODS), particularly halocarbons such as the long-lived chlorofluorocarbons (CFCs), bromine-containing halons, and methyl bromide. Through rapid catalytic reactions with ozone, the chlorine and bromine from these chemicals have depleted the protective ozone layer (see the [Stratospheric Ozone Levels](#) indicator).

Worldwide production and consumption of ODS are being progressively phased out under the provisions of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. In the U.S., EPA implements the Montreal Protocol as well as Title VI of the Clean Air Act to reduce the use and emissions of ODS. Over time, reducing the atmospheric loading of ODS is expected to result in global increases in stratospheric ozone. However, because some ODS have long atmospheric lifetimes, and because of pre-phaseout ODS stockpiling for post-phaseout use, atmospheric concentrations of ODS have only recently begun to stabilize and in some cases begun to decline. While some gases, like methyl chloroform, decay quickly in the atmosphere, other gases, like CFCs and halons, have atmospheric lifetimes on the order of hundreds or thousands of years.

Different measures are used to track long-term trends in atmospheric concentrations of ODS. First, the National Oceanic and Atmospheric Administration (NOAA) has developed an Ozone Depleting Gas Index (ODGI) as a measure of the combined contributions of ODS to stratospheric chlorine and bromine (Newman et al., 2007; NOAA, 2020; WMO, 2018). This aggregate index is calculated from ground-based measurements of numerous individual ODS at remote locations worldwide, with adjustments to account for the lag time for ODS to travel from the troposphere to the stratosphere. Separate ODGI values are reported for mid-latitudes and for Antarctica. For purposes of this indicator, mid-latitudes are considered 35 to 60 degrees north latitude, which roughly corresponds to latitudes for North America. An ODGI value of 100 percent represents the year with the highest potential for ozone depletion based on the NOAA measurements. Over mid-latitudes, this occurred in 1997, and over Antarctica, this occurred in 2001 and 2002. Conversely, an ODGI value of 0 percent represents the estimated load of ODS for 1980. The eventual return of ODS values to their 1980 levels (i.e., an ODGI value of 0 percent) is considered a significant milestone; however, some ODS-catalyzed stratospheric ozone depletion will still occur at these levels.

The second measure commonly used to track long-term trends is concentrations of individual ODS (e.g., carbon tetrachloride, methyl bromide) and groups of ODS (e.g., hydrochlorofluorocarbons, halons). The measure reported in this indicator is the equivalent effective chlorine concentration (EECI). These values represent ODS concentrations weighted by their potential to catalyze the destruction of stratospheric ozone.

This indicator presents ODS trends using both measures described above based on measurements

from the NOAA Climate Monitoring and Diagnostics Laboratory between 1992 and 2019. The longest running remote sampling locations include: Alert, Northwest Territories, Canada; Point Barrow, Alaska; Niwot Ridge, Colorado; Mauna Loa, Hawaii; American Samoa; Cape Grim, Tasmania, Australia; and the South Pole (Montzka et al., 1999). Because most ODS have long atmospheric half-lives, the ODS concentrations shown in this indicator reflect past and recent contributions from emissions sources within the U.S. and worldwide.

What the Data Show

ODGI values for mid-latitudes increased between 1992 and 1997 and then steadily decreased through 2019 (Exhibit 1). The 2019 value (53.4 percent) suggests that ODS levels have progressed 46.6 percent towards returning to their estimated 1980 values from their peak in 1997. Similarly, ODGI values for Antarctica increased between 1992 and 2002 before decreasing through 2019 (Exhibit 1). The recent value for Antarctica suggests that 2019 ODS levels in that region have progressed 22.1 percent of the way from peak levels to the 1980 levels.

Long-term trends in EECl concentrations of individual ODS vary across chemicals and region. For each substance, tropospheric EECl levels over mid-latitudes are consistently lower than the corresponding levels over Antarctica (Exhibits 2 and 3). In both regions, EECl concentrations of methyl chloroform decreased dramatically (i.e., by more than 98 percent) between 1992 and 2019. Over the same time frame, EECl concentrations for methyl bromide, carbon tetrachloride, and CFC-11 also decreased in both regions, but by smaller amounts (i.e., between 14 and 28 percent). On the other hand, EECl concentrations of several ODS increased in both regions between 1992 and 2019 (Exhibits 2 and 3). This occurred for halons, CFC-12, and some hydrochlorofluorocarbons.

While the concentration of CFC-11 decreased each year from 1995 to 2019, the rate of decrease slowed starting in 2014. In mid-2018, a higher than expected atmospheric concentration of CFC-11 was detected (Montzka et al., 2018). Atmospheric modeling suggested that these concentrations resulted from an increase in CFC-11 emissions from new production and use in eastern mainland China, inconsistent with the Montreal Protocol agreement to phase out global chlorofluorocarbon production and consumption by 2010 (Rigby et al., 2019). Following efforts from the United States and other parties to the Montreal Protocol to address the unexpected emissions, CFC-11 concentrations are again decreasing at their earlier rate, and no delay of the healing of the ozone layer is expected (Montzka et al., 2021).

In summary, although tropospheric concentrations of some ODS compounds have begun to decline, concentrations of others have not yet stabilized. The relatively slow decline of CFCs is generally a result of continued emissions of CFCs from stockpiles and their long atmospheric lifetimes. The increase in certain ODS likely results from continued emissions from stockpiles and continued production and consumption of certain ODS in both developed and developing countries.

Limitations

- The calculation of EECl depends on the understanding of the interactions and atmospheric residence times of many different gases; incorrect knowledge about these factors could affect trends in the EECl.
- EECl is calculated by weighting each ODS's concentration by the substance's ability to catalyze destruction of stratospheric ozone, or the ozone depletion potential. The ozone depletion potentials used to transform the data have inherent uncertainties, which can affect

the trend analyses.

- Factors additional to trends in halocarbons affect trends in stratospheric ozone. These factors include changes in climate (e.g., temperature, winds), changes in emissions and concentrations of trace gases like nitrous oxide and methane, and changes in aerosol loading such as occurs after an explosive volcanic eruption.

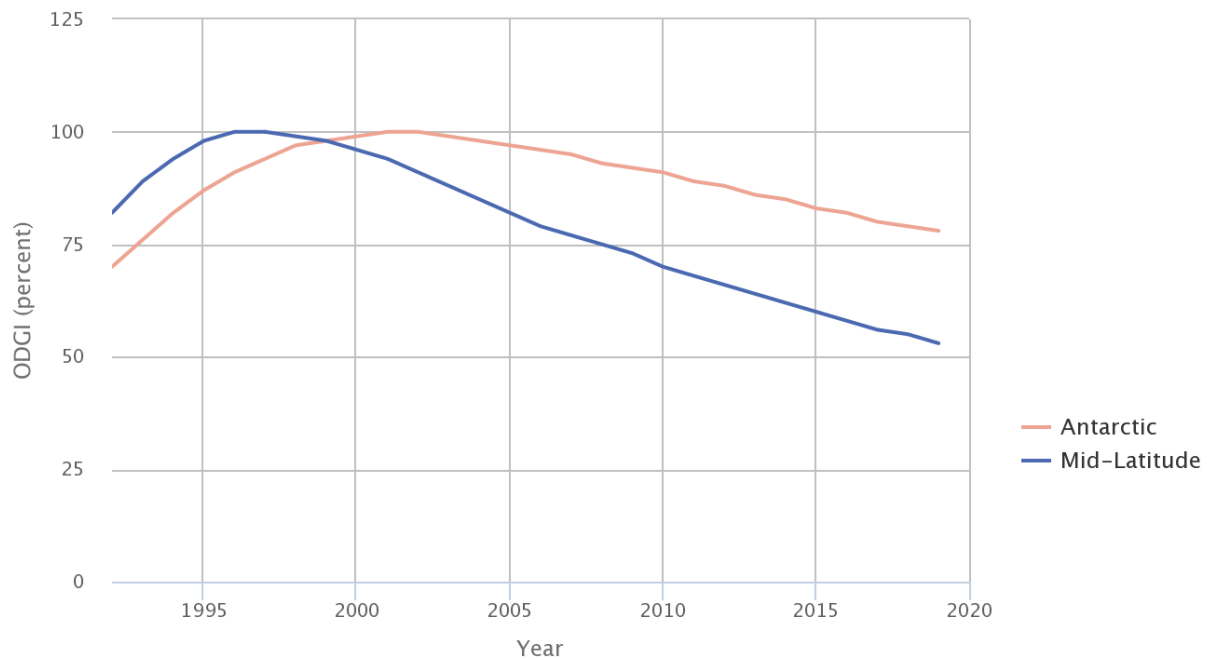
Data Sources

Concentrations of ODS presented in this indicator are based on measurements made by NOAA's Global Monitoring Division. The 1992–2019 data are taken from NOAA's Ozone Depleting Gas Index website (NOAA, 2020) (<https://www.esrl.noaa.gov/gmd/odgi/>).

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Exhibit 1. Ozone Depleting Gas Index (ODGI), 1992–2019

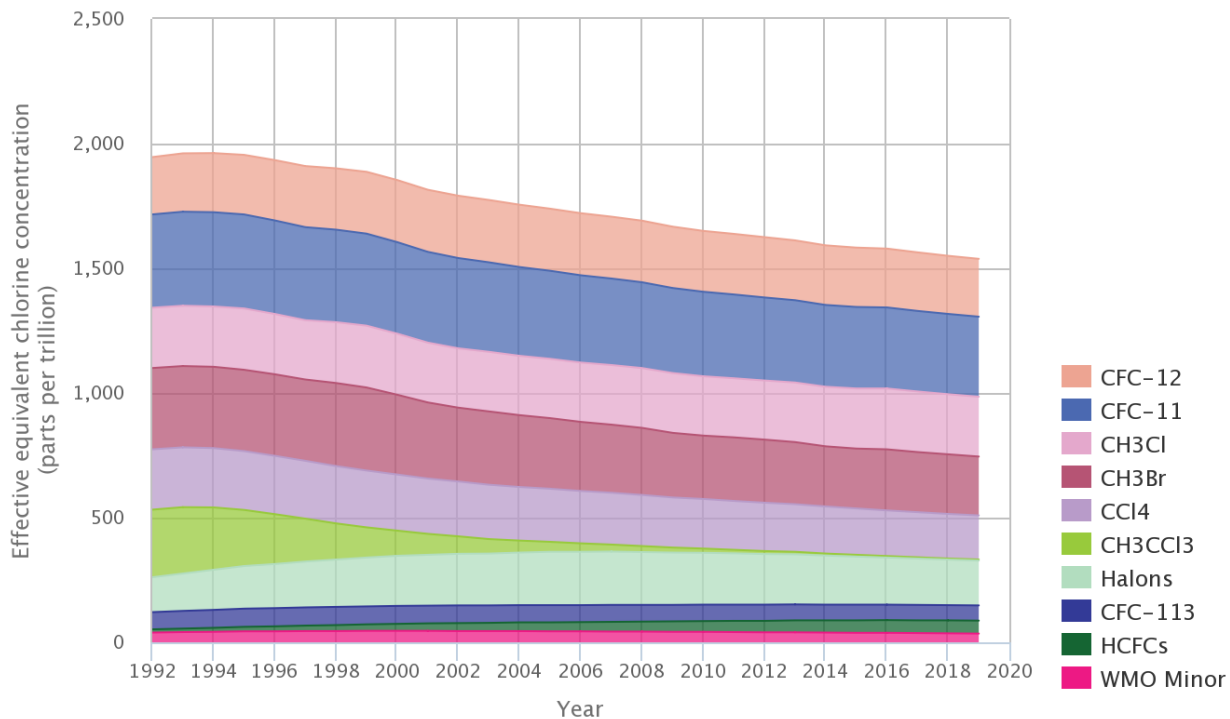


ODGI is a measure of the combined contributions of ozone-depleting substances due to stratospheric chlorine and bromine.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: NOAA, 2020

Exhibit 2. Mid-latitude stratospheric concentrations of ozone-depleting substances, 1992–2019



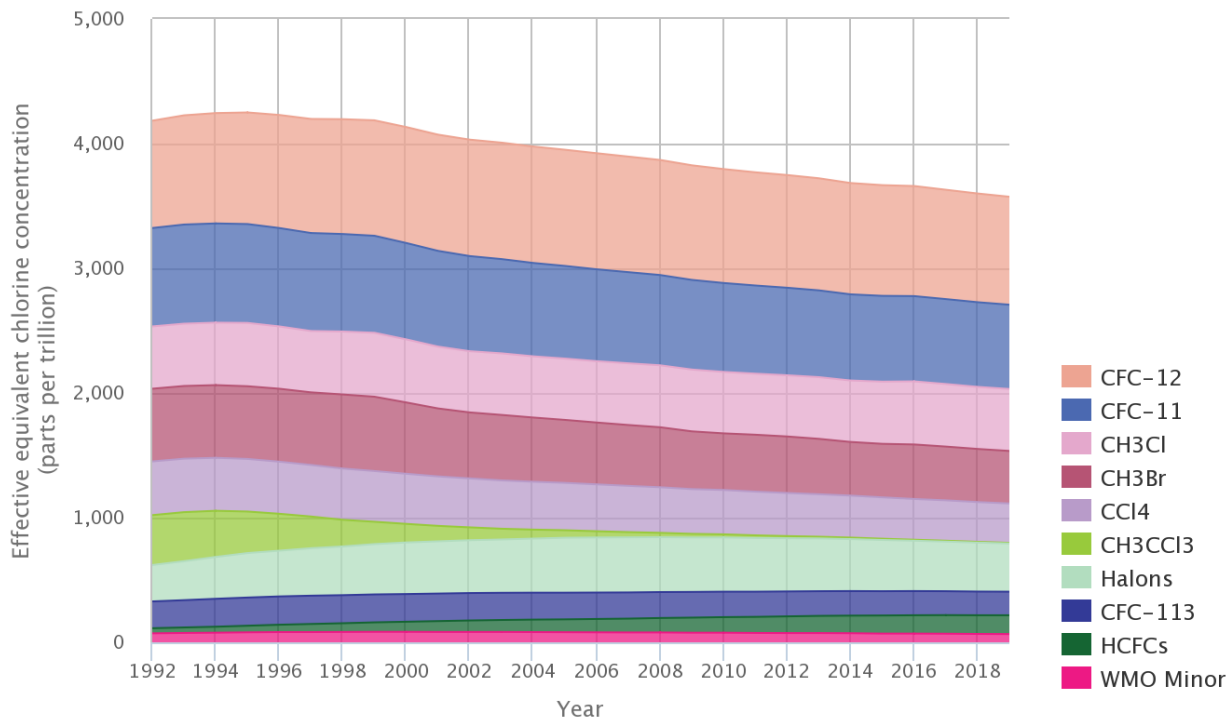
Effective equivalent chlorine (EECI) is typically used to represent atmospheric concentrations of ozone-depleting substances. The EECI of ozone-depleting substances is calculated from the substances' atmospheric concentrations and their potential to catalyze the destruction of stratospheric ozone.

“Halons” represents the aggregate of halon 1211, halon 1301, and halon 2402. “HCFCs” represents the aggregate of three hydrochlorofluorocarbons (HCFCs): HCFC-22, HCFC-141b, and HCFC-142b. “WMO minor” represents the aggregate of CFC-114, CFC-115, halon 2402, and halon 1201.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: NOAA, 2020

Exhibit 3. Antarctic atmospheric concentrations of ozone-depleting substances, 1992–2019



Effective equivalent chlorine (EECI) is typically used to represent atmospheric concentrations of ozone-depleting substances. The EECI of ozone-depleting substances is calculated from the substances' atmospheric concentrations and their potential to catalyze the destruction of stratospheric ozone.

The chlorofluorocarbons (CFCs) considered in this figure are CFC-11, CFC-12, and CFC-113. The halons considered in this figure are halon 1211 and halon 1301. The hydrochlorofluorocarbons (HCFCs) considered in this figure are HCFC-22, HCFC-141b, and HCFC-142b.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: NOAA, 2020