Indicator: Concentrations of Ozone-depleting Substances (017)

Ozone is a pollutant at the earth's surface but is very important in the stratosphere, where a layer of ozone helps shield Earth from the sun's ultraviolet (UV) radiation. UV-rays can cause skin cancer, cataracts, and other human health and ecological problems (EPA, 1996). Over recent decades, certain chemicals of human origin released at ground-level have migrated through the atmosphere and mixed into the stratosphere, where they have caused depletion of stratospheric ozone, especially over the polar regions. These chemicals, collectively known as ozone-depleting substances, include chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and others. Worldwide production of CFCs and other ozone-depleting substances is being progressively eliminated under the provisions of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, an international agreement ratified by more than 180 countries. Over time, reducing the atmospheric loading of ozone-depleting substances is expected to result in global increases in stratospheric ozone.

This indicator reflects concentrations of effective equivalent chlorine (EECl) in the lower atmosphere. EECl is derived by measuring concentrations of 10 chlorine- and bromine-containing gases in the lower atmosphere and calculating chlorine equivalents based on the ability of each gas to catalyze the destruction of ozone relative to the ability of chlorine to do so. Individual chlorine equivalent concentrations are then summed into the total EECl concentration and reported in parts per trillion by volume. While monitoring at some sites began as early as 1977, this indicator is based on monitoring since 1992 at 5-7 remote locations in Alert, North West Territories, Canada; Barrow, Alaska; Niwot Ridge, Colorado; Mauna Loa, Hawaii; American Samoa; Cape Grim, Tasmania, Australia; and the South Pole (NOAA 2003).

What the Data Show

The total abundance of ozone-depleting compounds in the lower atmosphere, expressed as chlorine equivalents, has decreased approximately 6% globally since its peak in 1994 (Figure 017-1). Of the individual compounds, total chlorine is declining, while bromine from industrial halons is still increasing, but at a slower rate than was occurring previously (WMO 2002). Observations in the stratosphere indicate that the total chlorine abundance is at or near a peak, while bromine abundances are probably still increasing (WMO 2002).

Indicator Limitations

- Persistent chemicals not monitored in this indicator (such as methyl halides and lesser halocarbons) contribute an additional 900 ppt to the EECl in today's atmosphere.
- The calculation of EECl depends on the understanding to the interactions and atmospheric residence times of many different gases; incorrect knowledge about these factors could affect trends in the EECl.

Data Sources

The data source for this indicator was NOAA's Climate Monitoring and Diagnostics Laboratory: ftp://ftp.cmdl.noaa.gov/hats/Total_Cl_Br/2004b%20update%20total%20EECl.xls

References

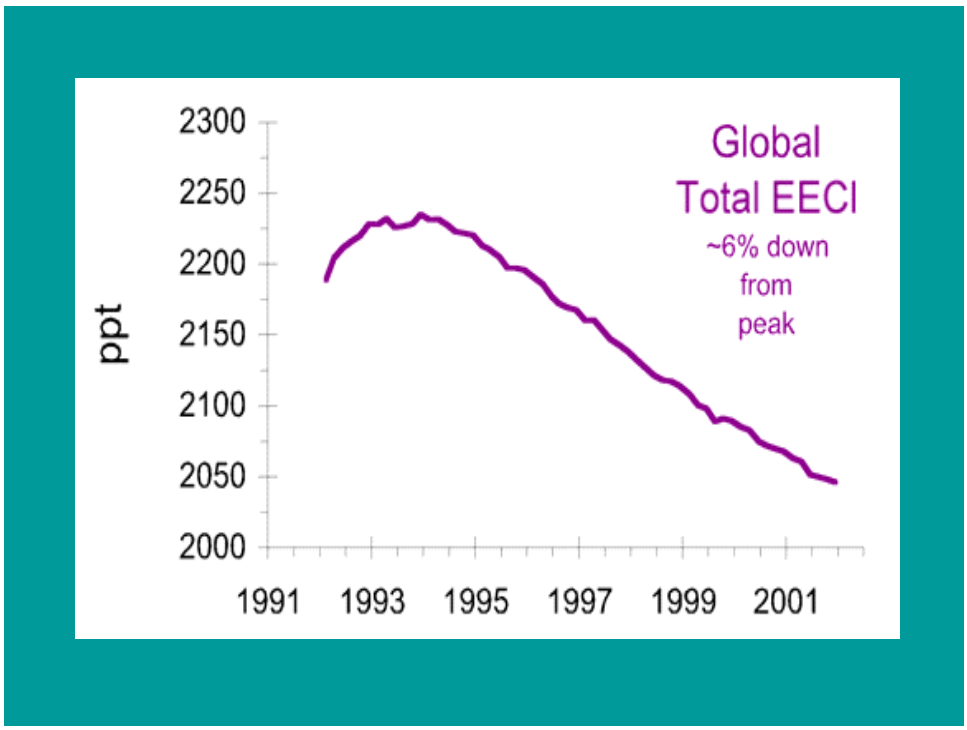
NOAA. 2003. *Climate Monitoring and Diagnostics Laboratory - Summary Report No. 27.* National Oceanographic and Atmospheric Administration, Boulder Colorado. http://www.cmdl.noaa.gov/publications/annrpt27/

World Meteorological Organization (WMO). Scientific Assessment of Ozone Depletion: 2002. Geneva, Switzerland. March 2003.

EPA, 1996. Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-cF. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, July 1996.

Graphics

Figure 017-1



R.O.E. Indicator QA/QC

Data Set Name: CONCENTRATIONS OF OZONE-DEPLETING SUBSTANCES
Indicator Number: 017 (89074)
Data Set Source: NOAA http://www.cmdl.noaa.gov/hats/graphs/graphs.html
Data Collection Date: UNKNOWN
Data Collection Frequency: unknown
Data Set Description: Concentrations of Ozone-depleting Substances
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, the data serve as an important basis for the periodic Scientific Assessment of Ozone Depletion published by the World Meteorological Organization and the United Nations Environment Program pursuant to Article 6 of the Montreal Protocol, and the data are peer reviewed both in the scientific literature and in conjunction with the assessments: http://www.wmo.ch/web/arep/reports/ozone_2002/01_title.pdf. A good description of the measurement protocols can be found at: http://www.cmdl.noaa.gov/publications/annrpt27/hats5.pdf. An earlier version of this indicator was published in Montza, et al. 1999, Present and future trends in the atmospheric burden of ozone-depleting halogens, Nature 398, 690.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The Climate Monitoring and Diagnostics Laboratory (CMDL) Halocarbons and other Atmospheric Trace Species (HATS) group of the National Oceanic and Atmospheric Administration has been analyzing air samples collected in flasks since 1977. Originally set up under the auspices of the Geophysical Monitoring for Climatic Change (GMCC) division of NOAA's Air Resources Laboratory (NOAA/ARL), this program involved the analysis of flask samples from Alert, North West Territories, Canada; Barrow, Alaska, USA; Niwot Ridge, Colorado, USA; Mauna Loa, Hawaii, USA; American Samoa; Cape Grim, Tasmania, Australia; and the South Pole. A description of the HATS Flask Sampling Plan can be found at http://www.cmdl.noaa.gov/noah/flask/flasks.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. It has been used to support the Scientific Assessment of Ozone Depletion published by the World Meteorological Organization and the United Nations Environment Program pursuant to Article 6 of the Montreal Protocol, and the data are peer reviewed both in the

scientific literature and in conjunction with the assessments: http://www.wmo.ch/web/arep/reports/ozone_2002/01_title.pdf.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator helps to answer the question, "What are the trends in outdoor air quality and effects on human health and ecological systems?" Because ozone depleting substances are well mixed in the troposphere away from immediate sources, the seven remote sampling sites provide a good indication of the tropospheric mixing ratios.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not Applicable.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

A description of the HATS Flask Sampling Plan can be found at http://www.cmdl.noaa.gov/noah/flask/flasks.html and at http://www.cmdl.noaa.gov/publications/annrpt27/hats5.pdf.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Links to the files containing datasets of CMDL measurements can be downloaded at the CMDL anonymous FTP area - http://www.cmdl.noaa.gov/infodata/ftpdata.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The NOAA Halocarbons and other Atmospheric Trace Species (HATS) group measures and interprets the distributions and trends of these species in the troposphere, stratosphere, and ocean with the best analytical instrumentation available. Continuing programs within HATS are based upon in situ and flask measurements of the atmosphere from the 4 CMDL baseline observatories and 10 cooperative stations. A list of the geographic locations can be found in the paper Halocarbons and other Atmospheric Trace Species. A copy of this paper can be downloaded from http://www.cmdl.noaa.gov/publications/annrpt26/5_1.pdf.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Accurate measurements of trace constituents in the atmosphere ability to accurately prepare compressed gas calibration standards. Standards for various halocarbons including chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), methyl halides, halons, chlorinated solvents, and other gases are prepared gravimetrically as primary standards in our laboratory. The concentrations of most of these standards are at part per trillion (ppt or pmol/mol) levels. These standards are then used to calibrate secondary and tertiary gas mixtures that are used within NOAA as well as other federal, state, and private laboratories world-wide. The secondary and tertiary standards normally contain dried, natural air that is collected using a pumping system located at Niwot Ridge, CO. QA procedures can be viewed at http://www.cmdl.noaa.gov/hats/standard/standard.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Hemispheric mixing ratios are estimated after weightingresults by sampling latitude, and these results are then averaged to estimatetropospheric, global means.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

For a description of factors affecting scientific understanding of atmospheric chlorine loading, see the Scientific Assessment of Ozone Depletion: 2002 at http://www.unep.org/ozone/pdfs/Scientific_assess_depletion/06-Chapter1.pdf.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. Also, research programs in key regions, utilizing an array of platforms including aircraft, balloons, ocean vessels and towers, complement the land-based information. A description of the Airborne Chromotograph for Atmospheric Trace Species (ACATS) can be found at http://www.cmdl.noaa.gov/hats/airborne/acats/.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The precision of this indicator depends on understanding the chemistry and behavior of the many different gases involved. For example, accurate estimates of the atmospheric lifetime of a gas are essential to assigning it the proper weight relative to other gases. As scientific understanding of atmospheric chemistry improves, calculations continue to be refined.