Effects of cfc on ozone layer pdf

Regardless of the external sound was Ozone Hole?, Distillation Podcast Episode 230, April 17, 2018, the Institute of Science History consists of two related events observed since the late 1970s of Ozone depletion: a constant drop of about four percent of the total amount of ozone in the Earth's atmosphere (ozone layer), and a much larger spring fall from stratospheric ozone around earth's polar regions. [1] The second phenomenon is called an ozone hole. In addition to these stratospheric events, there are also spring polar trofieric ozone depletion events. The main cause of ozone depletion and ozone hole are chemicals called ozone-consuming substances (ODS), specifically produced halocarbon coolers, solvents, repellents and foam blowing agents (chlorophylorocarbons (CFCs), HCFCs, halons). These compounds are spread from the surface and then transported into the stratosphere by turbulent mixing, mixing much faster than molecules can settle. [2] When they enter the stratosphere, they secrete halogen atoms through photodissosiation, which catalyses the disinteateration of oson (O_3) into oxygen (O_2). [3] It has been observed that both ozone layers increase as halocarbon emissions increase. Ozone depletion and increased ozone hole have created worldwide concern over cancer risks and other negative effects. The ozone layer prevents the most harmful wavelengths of ultraviolet (UV) light from passing through the Earth's atmosphere. These wavelengths cause skin cancer, sunburn, persistent blindness, and catarrage, which are projected to significantly increase as a result of ozone thinning, as well as damage to plants and animals. These concerns led to the acceptance of the Montreal Protocol in 1987, which prohibits the production of CFC, halon and other ozone-consuming chemicals. The ban came into force in 1989. Ozone levels stabilized in the mid-1990s and began to recover in the 2000s, the southern hemisphere jet stream stopped shifting toward the south pole and may even be back. [4] The recovery is expected to continue over the next century and the ozone hole is expected to reach pre-1980 levels by 2075. [5] In 2019, NASA reported that the ozone hole was the smallest since it was discovered in 1982. [6] [7] [8] The Montreal Protocol is considered the most successful international environmental treaty to date. [9] [10] An overview of the ozone cycle There are three forms (or allotropes) of oxygen in the ozone-oxygen cycle: oxygen atoms (O or atomic oxygen), oxygen gas (O_2 or diatomic oxygen) and ozone gas (O_3 or triatomic oxygen). Ozone occurs in the stratosphere when photodissociate after absorbing ultraviolet photons of oxygen molecules. This converts a single O_2 into two atomic oxygen radicals. Atomic oxygen radicals then combine with separate O_2 molecules to form two O_3 molecules. These ozone molecules absorb ultraviolet (UV) light, then divide the ozone O_2 molecule and an oxygen atom. The oxygen atom then merges with an oxygen molecule to refurbish the oson. This is an ongoing process that ends when an oxygen atom joins with an ozone molecule to make two O_2 molecules. $O + O_3 \rightarrow 2$ The total amount of ozone in the O_2 Stratosphere is determined by the balance between photochemical production and recombination. Ozone can be destroyed by a number of free radical catalysts; the most important are hydroxyl radical (OH·), nitric oxide radical (NO·), chlorine radical (Cl·) and bromine radical (Br·). The point is a representation that each type has an unmatched electron and is therefore highly reactive. All of these have both natural and man-made resources; currently, OH· most and NO· occurring naturally in the stratosphere, but human activity has significantly increased chlorine and bromine levels[11]. These elements are found in stable organic compounds, especially chloroflorocarbons, which can go to the stratosphere without being destroyed in the troposphere due to their low reactivity. After entering the stratosphere, the atoms Cl and Br are released from the main compounds by the movement of ultraviolet light, such as cfcl3 + electromagnetic radiation → Cl·. + · CFCl2 Ozone is a highly reactive molecule that easily reduces the form of more stable oxygen with the help of a catalyst. Cl and Br atoms destroy ozone molecules through various catalytic cycles. In the simplest example of such a cycle,[12] a chlorine atom reacts with an ozone molecule (O_3), taking an oxygen atom, creating chlorine monoxide (ClO) and ingesting an oxygen molecule (O_2). ClO reacts with a second ozone molecule, releasing chlorine atoms and releasing two oxygen molecules. Chemical shorthand for these gas phase reactions: $Cl\cdot + O_3 \rightarrow ClO + O_2$ A CHLORINE atom removes an oxygen atom from an ozone molecule $clo + O_3 \rightarrow Cl\cdot + 2\ O_2$ This CLO can also remove an oxygen atom from another ozone molecule; Chlorine is free to repeat this two-stage cycle The overall effect is a decrease in the amount of ozone, but the speed of these processes can be reduced by the effect of null cycles. More complex mechanisms have also been discovered in the lower stratosphere, leading to ozone destruction. Ozone cycle The lowest value of ozone measured by TOMS each year in the global monthly average ozone hole The lowest value of a single chlorine atom continuously destroys ozone for up to two years (timescale for moving back into the troposphere) (timescale for moving back into the troposphere) was not for reactions that took it out of this cycle by forming reservoir species such as hydrogen chloride (HCl) and chlorine nitrate ($ClONO_2$). Bromine is even more effective at destroying oson per atom than chlorine, but there is currently much less bromine in the atmosphere. Both chlorine and bromine contribute significantly to general ozone depletion. Laboratory fluorine and iodine atoms have also participated in similar catalytic cycles. But as fluorine atoms react rapidly with water and methane, they form a strongly bonded HF in the Earth's stratosphere, while organic molecules containing iodine react so quickly in the lower atmosphere that they cannot reach the stratosphere in significant quantities. A single chlorine atom can react with an average of 100,000 ozone molecules before being removed from the catalytic cycle. This condition plus the amount of chlorine released into the atmosphere each year by chloroflorocarbons (CFC) and hydrochlorofluorocarbons (HCFCs) shows the danger of CFC and HCFCs to the environment. [13] [14] Observations on the depletion of the ozone layer The ozone hole is usually measured by a decrease in the total colon ozone above a point on the Earth's surface. This is normally expressed in Dobson volumes; Abbreviated as DU. The most significant decrease in the ozo was in the lower stratosphere. Significant declines in colon ozone were observed using instruments such as the total ozone mapping spectrometer (TOMS) in the early 1970s and early summer. [15] Reductions of up to 70 percent continue in the ozone column (Farman et al.), which was observed in the austral (southern hemispheric) spring over Antarctica and first reported in 1985. Since the 1990s, the total colon ozone in Antarctica has remained 40-50 percent lower than pre-ozone hole values. [1] A gradual trend towards recovery was reported in 2016. [16] In 2017, NASA announced that the ozone hole was the weakest since 1988 due to hot stratospheric conditions. It is expected to recover around 2070. [17] The amount lost in the Arctic is more variable annually than in Antarctica. The biggest Arctic declines are in winter and spring, with the stratosphere reaches up to 30 percent when it is coldest. Reactions in polar stratospheric clouds (PSCs) play an important role in increasing ozone depletion. [18] PSCs are easier to form in extreme cold in the Arctic and Antarctic stratosphere. Therefore, ozone holes were first formed over Antarctica and are deeper. The early models failed to account for PSCs and predicted a gradual global depletion, so the sudden Antarctic ozone hole came as a surprise to many scientists. [19] [20] [21] It is better to talk at mid-latitude than holes from ozone depletion. Total colon oson decreased below pre-1980 values between 1980 and 1996 for medium latitude. At northern mid-latitude, from 1996 to 2009, the minimum value increased by about two percent, and regulations came into effect and the amount of chlorine in the stratosphere decreased. At the mid-latitude of the Southern Hemisphere, the total ozone remained constant during this time period. There is no significant trend in the tropics, because halogen-containing compounds did not have time to break down and release. and bromine atoms at tropical latitude. [1] [22] Large volcanic eruptions have been shown to have significant effects that consume the ozone layer, as observed by the Pinatubo Mt. eruption in the Philippines. [23] Ozone depletion also explains most of the decrease observed in stratospheric and upper tropospheric temperatures. [24] [25] The source of the temperature of the stratosphere is the absorption of OZONE and UV Radiation, so decreased ozone leads to cooling. Some stratospheric cooling is also predicted to increase greenhouse gases such as CO_2 and CFCs themselves; however, ozone-induced cooling appears to be dominant. [26] While estimates of ozone levels are difficult, the sensitivity of the models' estimates of the observed values and the agreement between different modeling techniques has increased steadily. [1] The World Meteorological Organization's Global Ozone Research and Monitoring Project-Report No. 44 emerges strongly in favor of the Montreal Protocol, but states that a UNEP 1994 Assessment overestanced ozone loss for the period 1994-1997. [27] CFCs in the atmosphere and compounds in the atmosphere Chloroflorocarbons (CFCs) and other halogenous ozone layer consuming substances (ODS) are mainly responsible for man-made chemical ozone depletion. The total amount of effective halogens (chlorine and bromine) in the stratosphere can be calculated and is known as the equivalent effective stratospheric chlorine (EESC). [28] CFCs were invented by Thomas Midgley, Jr. in the 1930s. Before the 1970s, it was used in air conditioning and cooling units, as aerosol spray thrusters and in cleaning operations of sensitive electronic equipment. It also emerges as by-products of some chemical processes. No significant natural resources have been identified for these compounds— their presence in the atmosphere is almost entirely due to human production. As mentioned above, when chemicals that consume such ozone layer reach the stratosphere, they are separated by ultraviolet light to release chlorine atoms. Chlorine atoms are a catalyst and can break down tens of thousands of ozone molecules before each is removed from the stratosphere. Given the longevity of CFC molecules, recovery times are measured over decades. It calculates that a CFC molecule can last an average of five to seven years from ground level to the upper atmosphere, during which time it can remain there for nearly a century, destroying a hundred thousand ozone molecules. [29] [Verification required] 1,1,1-Trichloro-2,2,2-trifluoroethane, also known as CFC-113a, is one of four newly discovered man-made chemicals in the atmosphere by a team at the University of East Anglia. CFC-113a is the only known CFC with increasing abundance in the atmosphere. Its source remains a mystery, but some suspect illegal production. The CFC-113a seems to have been accumulating unspmed since 1960. Between 2010 and 2012, jumped 45 percent. [30] [31] A study by an international research team published in the journal Nature found that since 2013, emissions from predominantly north-eastern China have secreted large quantities of chlorlororocarbon-11 (CFC-11) chemicals into the atmosphere. Without action, scientists predict that CFC-11 emissions will delay the recovery of the planet's ozone hole by a decade. [32] [33] [34] Computer modeling Scientists combined observational data with computer models, connecting the depletion of the ozone layer to the increase of man-made (anthropogenic) halogen compounds from CFCs. These complex chemical transport models (e.g. SLIMCAT, CLaMS-Stratosphere Chemical Lagrangian Model) work by combining measurements of chemical and meteorological fields with chemical reaction rate constants. CFC photolysis products describe important chemical reactions and transport processes that come into contact with ozone. Ozone hole causes ozone hole in North America during 1984 (abnormally hot, reducing ozone depletion) and 1997 (resulting in abnormally cold, increased seasonal depletion). Source: NASA[35] The Antarctic ozone hole is an area where the final ozone levels of the Antarctic stratosphere have dropped to 33 percent of pre-1975 values. The ozone hole occurs during the Antarctic spring, from September to early December, as strong western winds begin to circulate around the continent and create an atmospheric container. Inside this polar vortex, more than 50 percent of the lower stratospheric oson is destroyed during the Antarctic spring. [36] As described above, the main cause of the depletion of the ozone layer is the presence of chlorine-containing welding gases (primarily CFCs and related halocarbons). In the presence of UV light, these gases deer, releasing chlorine atoms, which continue to catalyze ozone destruction. Cl-catalysized ozone depletion may take place in the gas phase, but the pole has been significantly improved in the presence of stratospheric clouds (PSC). [37] These polar stratospheric clouds form in extreme cold in winter. Arctic winters are dark, forming three months without solar radiation (sunlight). The low sunlight contributes to the decrease in temperature and the closure of the polar vortex and cools the air. Temperatures are around or below −80 °C. These low temperatures create cloud particles. There are three types of PSC clouds-nitric acid trihydrate clouds, gradual cooling water-ice clouds, and fast cooling water-ice (nacreous) clouds-whose products provide surfaces for chemical reactions that will lead to ozone destruction in the spring. [38] These photochemical processes are complex but well understood. The basic observation is that normally, most of the chlorine in the stratosphere is found in reservoir compounds, especially chlorine nitrate ($ClONO_2$), and stable end products such as HCl. The formation of end products actually removes Cl from the ozon Process. The old sequester Cl can then be made available through light absorption at wavelengths shorter than 400 nm. [39] However, during the Antarctic winter and spring, reactions on the surface of polar stratospheric cloud particles convert these reservoir compounds into reactive free radicals (Cl and ClO). The process of removing clouds by converting NO_2 from the stratosphere into nitric acid in psc particles is called denitrification. This prevents the newly formed CLO from being converted to $ClONO_2$. The role of sunlight in ozone depletion is the biggest cause of Antarctic ozone depletion in the spring months. In winter, although PSCs are the most abundant, there is no light on the pole that drive chemical reactions. During spring, however, the sun is released from the important CLO, providing energy to drive photochemical reactions and melt the polar stratospheric clouds, which drives the hole mechanism. Towards the end of spring more warming temperatures break down the thinging in mid-December. Hot, ozone and NO_2-rich air flows through the lower latitude, pscs are destroyed, the advanced ozone depletion zone closes and the ozone hole closes. [40] Most of the destroyed ozone is in the lower stratosphere, which, unlike much smaller ozone depletion through homogeneous gas phase reactions, occurs primarily in the upper stratosphere. [41] It is common to misunderstoo complex issues such as public misconceptions about ozone depletion and ozone depletion. The limited scientific knowledge of the public has caused confusion about global warming[42] or the perception of global warming as a subset of the ozone hole. [43] Initially, classic green NGOs avoided using CFC depletion for the campaign because they thought the issue was too complex. [44] Much later, for example, Greenpeace's support for the CFC-without refrigerator, produced by former East German company VEB dkk Scharfenstein, became active. [44] [45] The metaphors used in the CFC debate (ozone shield, ozone hole) are not scientifically precise. The ozone hole is more of a depression, less a hole in the windshield. Ozone disappears with the layer, nor does there is a smooth thinning of the ozone layer. However, it resonated better with those who were not scientists and their concerns. [46] Ozone hole was seen as a hot problem and an near risk because they feared serious personal consequences such as skin cancer, catarmidated, damage to plants and reduced plankton populations in the ocean's fotic region,[47] he said. Not only at the policy level, but compared to climate change, ozone regulation has been much better defeated in public. Americans voluntarily moved away from aerosol sprays before the legislation went into effect, while climate change failed to provide comparable concern and public action. [46] A sudden description in 1985 the hole was widely found in the press. Particularly rapid ozone depletion in Antarctica has previously been dismissed as a measurement error. [48] The scientific consensus was established after the arrangement. [44] Although the Antarctic ozone hole has a relatively small impact on the global ozone, the hole has attracted a lot of public attention because: Many are concerned that ozone holes are beginning to appear in other parts of the world, but it is a smaller ozone dimple ever seen around the Arctic during the Arctic spring. Ozone decreased at mid-latitude, but to a much smaller extent (a decrease of about 4-5 percent). If stratospheric conditions become more severe (colder temperatures, more clouds, more active chlorine), the global ozone may desize at a greater rate. Standard global warming theory predicts the stratosphere will cool down. [49] When the Antarctic ozone hole is fragmented every year, when the ozone layer is depleted, the air that the ozone layer runs out drifts into nearby areas. Up to 10 percent drop in ozone levels has been reported in New Zealand in the month when the Antarctic ozone hole dissed,[50] ultraviolet-B radiation densities have increased by more than 15 percent since the 1970s. [51] [52] The consequences of depletion of the ozone layer because the ozone layer absorbs uvb ultraviolet light from the sun, the depletion of the ozone layer increases surface UVB levels (equal to all other) , which can cause damage, including an increase in skin cancer. That was the reason for the Montreal Protocol. Although declines in stratospheric ozone are well linked to CFCs and increases in surface UVB, there is no direct observational evidence linking ozone depletion to higher skin cancer and the insidance of eye damage in humans. It is almost impossible to check statistics for lifestyle changes over time because UVA, which has also been implicating in some forms of skin cancer, is not absorbed by ozone. Ozone depletion can also affect wind patterns. [53] While increased UV Ozone is a minority component in the Earth's atmosphere, UVB is most responsible for absorption of radiation. The amount of UVB radiation passing through the ozone layer is exponentially reduced by the thickness and density of the layer's tilt path. When stratospheric ozone levels fall, higher UVB levels reach the Earth's surface. [1] [54] Uv-guided phenolic formation in tree rings dates back to the late 1700s, when ozone depletion began at northern latitude[55] in October 2008, the Ecuadorian Space Agency published a report called HIPERION. The study used data from the last 28 years of ground instruments and 12 satellites of various countries in Ecuador and found that UV Radiation is much higher than expected UV radiation reaching equatorial latitude, with the UV Index rising to 24 in Quito; DSA sees 11 as an extreme index and a major risk to health. The report found that depleted ozone levels The planet's mid-latitude is already endangering large populations in these regions. [56] Later, CONIDA, the Peruvian Space Agency, published its own study, which revealed almost the same findings as the Ecuadorian study. The main public concern about the biological effects ozone hole has been the effects of increased surface UV radiation on human health. So far, ozone depletion in most places has usually been several percent, and as mentioned above, direct evidence of health damage is present at most latitude. If the high levels of depletion seen in the ozone hole were widespread all over the world, the effects could have been much more dramatic. As the ozone hole over Antarctica has grown in some cases large enough to affect parts of Australia, New Zealand, Chile, Argentina and South Africa, environmentalists have been concerned that the increase in surface UV could be significant. [57] Ozone depletion greatly affects all of UV's human health, both positive (including vitamin D production) and negative (including sunburn, skin cancer and catarate). In addition, increased surface UV leads to increased tropospheric ozone, which is a health risk for humans. [58] Basal and scuamous cell carcinomas have been linked to the most common forms of skin cancer in humans, basal and scuamous cell carcinoms, strong UVB exposure. The mechanism by which UVB triggers these cancers is well understood—absorption of UVB radiation causes the bases of pyrimidine in the DNA molecule to form dimers, causing transcription errors when DNA multiplies. Although treatment of scuamous cell carcinoma sometimes does not require extensive reconstructive surgery, these cancers are relatively mild and rarely fatal. By combining epidemiological data with the results of animal studies, scientists estimate that every one percent reduction in long-term stratospheric ozo will increase the incidence of these cancers by 2%. [59] Malignant melanoma Another form of skin cancer, malignant melanoma, is much less common but much more dangerous, being fatal in about 15-20 percent of diagnosed cases. The relationship between malignant melanoma and ultraviolet exposure is not yet fully understood, but both UVB and UVA are seen to play a role. Because of this uncertainty, it is difficult to predict the effect of ozone depletion on the indentity of melanoma. One study showed that a 10 percent increase in UVB radiation was associated with a 19 percent increase in melanomas for men and 16 percent for women. [60] A study conducted at Punta Arenas in the southern tip of Chile found a 56 percent increase in melanoma over a seven-year period and a 46 percent increase in non-melanoma skin cancer, and an increase in ozone and UVB levels. [61] Epidemiological studies of cortical catarage show an relationship between ocular cortical catarth and UVB exposure using raw approaches to exposure and various catarage evaluation techniques. A detailed assessment of ocular exposure to ocular UVB was conducted in a study on chesapeake bay watermen, in which increases in average annual ocular exposure were associated with an increased risk of cortical opacity. [62] In this heavily exposed group of predominantly white males, evidence linking cortical opacity to sunlight was the strongest to date. Based on these results, ozone depletion is estimated to cause hundreds of thousands of additional catarms by 2050. [63] Increased tropospheric ozone Leads to increased surface UV increased tropospheric ozone. Ground-level ozone is generally considered a health risk, as ozone is toxic due to its strong oxidant properties. The risks are particularly high for young children, the elderly and those with asthma or other breathing difficulties. Currently, UV radiation action on ozone vehicle exhaust combustion gases at ground level is mainly produced. [64] Vitamin D production is produced on the skin with ultraviolet light. Thus, high UVB exposure raises human vitamin D in the years to come. [65] Recent research (primarily since the Montreal Protocol) shows that many people have less optimal vitamin D levels. Specifically, in the U.S. population, the lowest quarter of vitamin D (<17.8 ng/ml) was found using information in relation to an increase in mortality caused by the general population in the National Health and Nutrition Review Survey. [66] Although the blood level of vitamin D exceeding 100 ng/ml appears to be associated with excessive blood calcium and high mortality, the body has mechanisms that block sunlight that produces vitamin D that exceed the body's requirements. [67] A November 2011 report by scientists from the Zoological Institute in London found that whales off the Coast of California showed a sharp increase in sun damage, and that they feared that the thinning ozone layer was to blame. [68] The study photographed and received skin biopsy of more than 150 whales in the Gulf of California and found widespread evidence of epidermal damage associated with acute and severe sunburn, and dna had cells that formed when damaged by UV radiation. The findings show that increased UV levels as a result of ozone depletion are responsible for observed skin damage, likewise human skin cancer rates have been on the rise in recent years. [69] Apart from whales, many other animals, such as dogs, cats, sheep and terrestrial ecosystems, are also exposed to the negative effects of increased UV-B radiation. [70] The effects on products are expected to affect plants as UV radiation increases. Economically important plant species, such as rice, depend on cyanobacteria living in their roots to keep nitrogen. Cyanobacteria are sensitive to UV rays and are affected by the increase. [71] Despite mechanisms for reducing or repairing effects In ultraviolet radiation, plants have a limited ability to adapt to increasing levels of UVB, so plant growth can be directly affected by UVB radiation. [72] The effects of the ozone layer on plant life and allowing excessive UVB radiation are initially assumed to increase damage to plant DNA. Reports have found that when plants are exposed to UVB radiation similar to stratospheric ozone depletion, there is a significant change in plant height or leaf mass, but a small decrease in fever showed the response in the field of biomass and leaves. [73] However, UVB radiation has shown to reduce quantum efficiency in photosistem II. [74] UVB damage occurs only under extreme exposure, with uvb-absorbing flavonoids present in most plants, which allows it to adapt to existing radiation. Throughout development, radiation-affected plants are more affected by not being able to cut light with a larger leaf area than endangering photosynthetic systems. [75] Damage from UVB radiation is more likely to be more important to the interactions of species than plants. [76] If chloroflorocarbons were not banned, public policy NASA projections of stratospheric ozone concentrations do not know the exact extent of the damage caused by CFCs to the ozone layer and have been unknown for decades; however, significant decreases were observed in the colon ozone. The Montreal and Vienna conventions were established long before a scientific consensus was established or significant uncertainties in the field of science were resolved. [44] The ozone case is comparable to that of yachtsmen, such as easy-to-understand briding metaphors such as ozone shields or ozone holes. [46] Americans voluntarily moved away from aerosol sprays, resulting in a 50 percent loss of sales even before the legislation went into effect. [46] After a 1976 report by the United States National Academy of Sciences concluded that credible scientific evidence supported the ozone depletion hypothesis,[77] several countries, including the United States, Canada, Sweden, Denmark and Norway, moved to eliminate the use of CfC in aerosol spray ball. [78] At the time, this was considered a first step towards a more comprehensive regulatory policy, but progress in this direction slowed in later years due to the combination of political factors (the ongoing resistance of the halocarbon industry and a general change in environmental regulation in the first two years of the Reagan administration) and scientific advances (subsequent National Academy assessments showing that initial estimates of the magnitude of ozone depletion were extremely low). great). A critical DuPont production patent for Freon was set to expire in 1979. The United States banned the use of CFC in aerosol cases in 1978. [78] The European Community rejected proposals to ban CFCs in aerosol sprays and continued to be used as a cooler. he did. to clean the circuit cards. Worldwide CFC production fell sharply after the U.S. aerosol ban, but by 1986 it had almost returned to the 1976 level. [78] In 1993, DuPont Canada closed its CFC facility. [79] With the appointment of William Ruckelshaus as director of the U.S. Environmental Protection Agency to replace Anne M. Burford, the U.S. government's stance began to change again in 1983. Under Ruckelshaus and his successor Lee Thomas, the EPA pushed for an international approach to halocarbon regulations. In 1985, twenty countries, including many of the major CFC producers, signed the Vienna Convention for the protection of the ozone layer, creating a framework on international regulations on substances that consume the ozone layer. In the same year, the discovery of the Antarctic ozone hole was announced and public interest in the issue was revived. In 1987, representatives from 43 countries signed the Montreal Protocol. Meanwhile, the halocarbon industry changed its position and began supporting a protocol to limit CFC production. But the shift was not on par with DuPont acting faster than its European counterparts. DuPont may be fearful of increased skin cancer-related court action, especially as the EPA published a study in 1986 claiming that an additional 40 million cases and 800,000 cancer deaths were expected in the U.S. over the next 88 years. [80] The EU changed its stance after Germany stopped defending the CFC industry and began supporting moves to regulate it. The government and industry in France and the UK tried to defend the CFC manufacturing industries even after the Montreal Protocol was signed. [81] In Montreal, participants agreed to freeze CFC production at 1986 levels and reduce production by 50 percent by 1999. [78] After a series of scientific discoveries to Antarctica revealed convincing evidence that the ozone hole was caused by chlorine and bromine from man-made organophagens, the Montreal Protocol was strengthened at a meeting in London in 1990. Participants agreed to phase out CFCs and halons in non-Article 5 countries by 2000 and in Article 5 (less advanced) signers by 2010 ,except for a very small amount marked for certain basic uses, such as asthma inhaler. [82] At a meeting in Copenhagen in 1992, the phase-out date was moved until 1996. [82] At the same meeting, methyl bromide (MeBr), a fumigant used in agricultural production, was added to the list of controlled substances. For all items controlled under the protocol, phaseout programmes for less developed countries were delayed ('Article 5(1)') and the phase in those countries was supported by specialization, technology and money transfers from the parties to the Article 5(1) Protocol. In addition, exemptions from programmes agreed under the Basic Use Exemption (EUE) process and under Critical Use for substances other than methyl bromide Process for methyl bromide (CUE). [83] [84] Civil society, especially NGOs, played critical roles in the evaluation of compliance with the Vienna Conference, the Montreal Protocol and later at every stage of policy development. [85] [86] [87] [88] Large companies claimed there was no alternative to HFC. [89] At a technology institute in Hamburg, Germany, an ozone-safe hydrocarbon cooler consisting of a mixture of propane and butane from hydrocarbon gases was suited, attracting the attention of the non-governmental organization Greenpeace (NGO) in 1992. Greenpeace called it Greenfreeze. [90] [91] The NGO later received the UNEP award in 1997, successfully working with a small, hard-working company to market a device that began in Europe, then Asia and then Latin America. [92] [93] By 1995, Germany had made CFC refrigerators illegal. [93] Since 2004, companies such as Coca-Cola, Carlsberg and IKEA have been forming a coalition to promote ozone-protected Greenfreeze units. Production spread to companies such as Electrolux, Bosch and LG, and by 2008 sales had reached nearly 300 million refrigerators. [92] [94] In Latin America, a domestic Argentine company began production of Greenfreeze in 2003, while the giant Bosch in Brazil began a year later. [95] [96] By 2013, it had been used by nearly 700 million refrigerators, and refrigerators made up about 40 percent of the market. [89] However, change in the United States has been much slower. To some extent, CFCs were being replaced with less harmful hydrochloroflorocarbons (HCFCs), but concerns about HCFCs remain. In some applications, hydrofluorocarbons (HFCs) cfcs. HFC was used instead of containing no chlorine or bromine, although they are strong greenhouse gases that do not contribute to ozone depletion at all. The best known of these compounds is probably the HFC-134a (R-134a), which has replaced the CFC-12 (R-12) in largely automobile air conditioners in the United States. In laboratory analysis (an ancient basic use), substances that consume the ozone layer can be replaced with various other solvents. [97] Chemical companies such as Du Pont downplayed greenfreeze even as German technology, maneuvering the EPA to block technology in the United States until 2011. [98] [99] [100] [101] Greenpeace-promoted Unilever and General Electric's Ben & Jerry's expressed official interest in 2008, which is in accordance with the EPA's final approval. [92] More recently, policy experts have defended efforts to link ozone conservation efforts to climate protection efforts. [103] [104] Many ODS also have agents that are some thousands of times more powerful in greenhouse gases, forcing the transporter than carbon dioxide in the short to medium term. Thus, policies that protect the ozone layer have had benefits in reducing climate change. In fact, reducing radiative coercion due to ODS is probably the true level of climate change impacts of other greenhouse gases and was in charge Slowing global warming from the mid-90s onwards. [105] [additional citations(s) required] Policy decisions made in one area affect the costs of the other and the effectiveness of environmental improvements. ODS requirements in the marine industry IMO has changed in Regulation 12 of MARPOL Appendix VI on substances consuming the ozone layer. As of July 1, 2010, all ships where MARPOL Appendix VI applies must have a list of equipment used for substances consuming the ozone layer. The list should list the name of the ODS, the type and location of the equipment, the amount and date of the kg. All changes made since then must be saved in an ODS Registry that records all intended or unwanted versions of the atmosphere. In addition, new ODS supply or landing at coastal facilities should also be recorded. Expectations of ozone depletion ozone levels stabilized and began to recover in the 1990s after the Montreal Protocol. They are predicted to reach pre-1980 levels by 2075. [5] Gas trends consuming the ozone layer have led to a decrease in CFC emissions, while atmospheric concentrations of the most important compounds are decreasing. These substances are gradually being removed from the atmosphere; Since peaking in 1994, the level of Effective Equivalent Chlorine (EECl) in the atmosphere had dropped nearly 10 percent in 2008. The decrease in chemicals consuming the ozone layer has also been significantly affected by the reduction of chemicals containing bromine. Data show that important natural resources are available for atmospheric methyl bromide (CH_3Br). [1] The phase-out nitrogen oxide (N_2O) of CFCs is not covered by the Montreal Protocol, has become the highest emitted ozone-consuming substance, and a review of the IPCC's ozone observations and model calculations in 2005 concluded that the amount of global ozone is currently approximately balanced. While significant year-to-year variability is not expected, including the polar regions where depletion is the largest, the ozone layer is expected to begin to recover in the coming years due to the decrease in the ozone layer in full compliance with the Montreal Protocol. [107] The Antarctic ozone hole is expected to continue for decades. Ozone concentrations in the lower stratosphere over Antarctica will increase by 5-10 percent by 2020 and return to pre-1980 levels between 2060 and 2075. This is due to revised estimates of atmospheric concentrations of substances consuming the ozone layer, including future use of a larger estimate in developing countries, 10-25 years later than previously estimated in assessments. Another factor that can prolong the depletion of the ozone layer is the withdrawal of nitrogen oxides from the top of the stratosphere due to changing wind patterns. [108] A gradual trend towards recovery was reported in 2016. [16] In 2019, the ozone hole was the smallest in three decades. the hot polar stratosphere weakens the polar thinging. [109] See also the history of research: The ozone-oxygen cycle The basic physical and chemical processes that led to the formation of an ozone layer in the Earth's stratosphere were discovered by Sydney Chapman in 1930. Short wavelength UV radiation divides an oxygen (O_2) molecule into two oxygen (O) atoms, which combine with other oxygen molecules to form ozone. Ozone, an oxygen atom and an ozone molecule are removed from two oxygen molecules, namely the $O+O_3 \rightarrow$ re-combine to form $2O_2$. In the 1950s, David Bates and Marcel Nicolet presented evidence that various free radicals, particularly hydroxyl (OH) and nitric oxide (NO), could catalyte this recombination reaction and reduce the total amount of ozone. These free radicals were known to be in the stratosphere and were therefore considered part of the natural balance - in their absence it was predicted that the ozone layer would be twice as thick as it is now. In 1970, Paul Crutzen pointed out that nitrogen oxide (N_2O) emissions, a stable and long-lasting gas produced by soil bacteria, could affect the amount of nitric oxide (NO) in the stratosphere. Crutzen showed that nitrogen oxide lives long enough to reach the stratosphere, where it is converted to no. Crutzen later stated that increased fertilizer use may have led to an increase in nitrogen oxide emissions on the natural background, which would lead to an increase in the amount of NO in the stratosphere. Thus, human activity can affect the stratospheric ozone layer. The following year Crutzen and (independently) Harold Johnston suggested that NO emissions from supersonic passenger planes flying in the lower stratosphere could also consume the ozone layer. However, more recent analysis by David W. Fahey, an atmospheric scientist at the National Oceanic and Atmospheric Administration in 1995, found that if a fleet of 500 supersonic passenger planes were operated, the drop in the ozo would be between 1-2 percent. [110] Fahey stated that this would not be a showstopper for the development of advanced supersonic passenger aircraft. [111] The Rowland-Molina hypothesis was suggested in 1974 by Frank Sherwood Rowland, Professor of Chemistry at the University of California, Irvine, and Mario J. Molina, a postdoetal associate professor, that long-lasting organic halogen compounds such as CFCs could be similar, as Crutzen suggested for nitrogen oxide. James Lovelock had recently discovered that almost all of the CFC compounds produced since its invention in 1930 were still in the atmosphere during a cruise across the South Atlantic in 1971. Molina and Rowland concluded that CFCs such as N_2O would also reach the stratosphere, where they were separated by UV rays and would secrete chlorine atoms. A year ago, Richard Stolarski and Ralph Cicerone of the University of Michigan edict that Cl was more efficient at catalysing than HAYR. Ozone. Similar results were from Harvard University's Michael McElroy and Steven Wofsy. But both groups have not noticed that CFCs are a potentially large source of stratospheric chlorine, instead researching the possible effects of HCl emissions from the Space Shuttle, which are much smaller. The Rowland-Molina hypothesis was strongly debated by representatives of the aerosol and halocarbon industries. DuPont Chairman said the ozone depletion theory is a science fiction tale... a load of garbage ... It's total. [112] Robert Abplanalp, president of the Precision Valve Company (and inventor of the first practical aerosol spray valve), wrote a letter to the Chancellor of UC Irvine to complain about Rowland's public statements. [113] However, most of the basic assumptions made by Rowland and Molina were confirmed by laboratory measurements and direct observation in the stratosphere. Concentrations of welding gases (CFCs and related compounds) and chlorine reservoir species (HCl and $ClONO_2$) were measured throughout the stratosphere, and showed that CFCs were indeed the main source of stratospheric chlorine and that almost all of the emitted CFCs would eventually reach the stratosphere. Measuring chlorine monoxide (ClO) in the stratosphere by James G. Anderson and his collaborators was even more convincing. Cl radicals produced as a result of cl's reaction with ozone were not only present in the stratosphere, but also played a role in the destruction of ozone. McElroy and Wofsy expanded Rowland and Molina's work by demonstrating that bromine atoms are more effective catalysts for ozone loss than chlorine atoms, and argued that bromide organic compounds commonly used in fire extinguishers are a potentially large source of stratospheric bromine. In 1976, the United States National Academy of Sciences published a report conceiting that the ozone depletion hypothesis was strongly supported by scientific evidence. In contrast, the United States, Canada and Norway banned the use of CFC in aerosol spray crates in 1978. According to preliminary estimates, if CFC production continued at 1977 levels, total atmospheric ozone would reach a constant state 15 to 18 percent below normal levels a century later. By 1984, when better evidence of the rate of critical reactions was available, this estimate was changed to 5 to 9 percent constant state depletion. [114] Crutzen, Molina and Rowland were awarded the Nobel Prize in Chemistry in 1995 for their work on stratospheric ozone. Antarctic ozone hole The discovery of an Antarctic ozone hole by British Antarctic Research scientists Farman, Gardiner and Shanklin (first reported in a paper in Nature in May 1985[115]) shocked the scientific community because the decline in polar ozone was much greater than anyone else's. Expected. [48] Satellite measurements (TOMS onbord Nimbus 7) showing excessive depletion of oson around the South Pole were made available at the same time. [116] However, they were initially unreasonably rejected by data quality control algorithms (filtered as errors because the values were unexpectedly low); The ozone hole was detected only in satellite data. [81] When the software was restarted without flags, the ozone hole was seen until 1976. [117] Susan Solomon, an atmospheric chemist at the National Oceanic and Atmospheric Administration (NOAA), suggested that chemical reactions in polar stratospheric clouds (PSCs) in the cold Antarctic stratosphere caused a huge increase in the amount of chlorine found in active, ozone-destroying forms, despite being localized and seasonal. Polar saltospheric clouds in Antarctica occur only at very low temperatures, low to −80 °C and early spring conditions. In such cases, the cloud's ice crystals provide a suitable surface for converting non-reactive chlorine compounds into reactive chlorine compounds that can easily consume oson. Moreover, the polar vortex formed over Antarctica is very tight and the reaction on the surface of cloud crystals is very different from when it occurs in the atmosphere. These conditions led to the formation of ozone hole in Antarctica. This hypothesis was first confirmed precisely by laboratory measurements and then direct measurements, from ground and high-altitude aircraft, at very high concentrations of chlorine monoxide (CLO) in the Antarctic stratosphere. [118] Alternative hypotheses that make the ozone hole attractive to changes in solar UV radiation or changes in atmospheric circulation patterns have also been tested and shown to be indefensible. [119] Meanwhile, analysis of ozone measurements from the worldwide network of ground-based Dobson spectrophotometers led an international panel to conclude that the ozone layer was depleted at all latitude outside the tropics. [22] These trends were confirmed by satellite measurements. As a result, major halocarbon producing countries have agreed to phase out the production of CFCs, halons and related compounds, a process completed in 1996. Since 1981, the United Nations Environment Programme, under the auspices of the World Meteorological Organization, has taken a series of technical reports on the Scientific Assessment of Ozone Depletion based on satellite measurements. The 2007 report showed that the hole in the ozone layer has healed, the youngest in nearly a decade. [120] In the 2010 report, global ozone and ozone have not edicted in the Arctic and Antarctic regions in the last decade, but are not yet increasing. The ozone layer outside the polar regions pre-1980 levels some time before the middle of this century. In contrast, the spring ozone hole over Antarctica is expected to recover much later. [121] In 2012, NOAA and NASA said warmer temperatures above Antarctica led to the second-smallest seasonal ozone hole of an average of 17.9 million square kilometers in 20 years. The hole reached its biggest size of the season on September 22, reaching up to 21.2 million square kilometres. [122] A gradual trend towards recovery was reported in 2016[16] and 2017. [123] Ozone loss is reported to be significant even at saturation altitudes. [124] The hole in the ozone layer above the Earth's South Pole affected atmospheric circulation in the Southern Hemisphere up to the ewatt. [125] The ozone hole affected atmospheric circulation up to the tropics, and the amount of precipitation increased at low, subtropical latitude in the Southern Hemisphere. On March 3, 2005, the journal Nature[126] published an article linking 2004's unusually large Arctic ozone hole to solar wind activity. On March 15, 2011, about half of the ozone at the North Pole was destroyed, resulting in a record loss of ozone layer. [127] [128] [129] This change was linked to increasingly cold winters in the Arctic stratosphere at an altitude of about 20 km (12 miles), a change associated with global warming in a relationship that is still under investigation. [128] On March 25, ozone loss was the biggest loss compared to previous winters, with the possibility of an ozone hole. [130] This requires the amount of ozone to drop below the 250 dobson units recorded in central Siberia. [130] The thinning layer is expected to affect parts of Scandinavia and Eastern Europe on 30-31 March. [130] A study published october 2, 2011 in the journal Nature stated that between December 2010 and March 2011, 80 percent of the ozone in the atmosphere was destroyed at an altitude of about 20 kilometers (12 miles) above the surface. [131] The level of ozone depletion was as severe as what scientists said could be compared to the ozone hole that occurs over Antarctica each winter. [131] According to the study, for the first time, enough loss occurred to describe it as a thought-good Arctic ozone hole. [131] The study analyzed data from the Aura and CALIPSO satellites and determined that larger-than-normal ozone loss, cold air at the North Pole, was due to 30 days more time than normal, which allows the creation of ozone-destroying chlorine compounds. [132] According to Lamont Poole, co-author of the study, cloud and aerosol particles containing chlorine compounds were found abundantly in the Arctic by mid-March 2011 – much later than usual – with average amounts at some altitudes similar to those observed in Antarctica, and In most Arctic winters, it is larger than the near-zero values seen in March. [132] In 2013, researchers analyzed the data and found that the 2010-11 Arctic event did not reach ozone depletion levels and was not classified as a real hole. A hole in the ozone is generally classified as 220 Dobson units or lower; [133] The Arctic hole did not approach such a low level. [134] [135] It has since been classified as a mini-hole. [136] Following ozone depletion in 1997 and 2011, the 90% drop in Ozone was measured by air balloons at the Arctic in March 2020, as they recorded 3.5 pieces of ozone per million, normally due to cold weather recorded since 1979 and a strong polar vortex that allowed chemicals including chlorine and bromine. , to nibble. [137] In 2020, a rare hole was examined in the atmosphere above the Arctic as a result of unusually low temperatures. [138] [139] The Tibetan ozone hole has an ozone hole over Tibet from time to time, while colder winters are more affected. In 2006, an ozone hole of 2.5 million square kilometers was detected over Tibet. [140] Also in 2011, an unprecedented hole appeared in the ozone hole and the Arctic in the mountainous regions of Tibet, Xinjiang, Qinghai and Hindu Kush, but was much less dense than those over the North Pole or Antarctica in Tibet. [141] Research of potential depletion by storm clouds showed in 2012 that the same process that produces ozone hole over Antarctica occurred over summer storm clouds in the United States, and so there may also be no ozone. [142] [143] Ozone depletion and global warming Main article: Ozone depletion and global warming, among others, Robert Watson had a role in science evaluation and ozone depletion and global warming regulatory efforts. [44] Before the 1980s, the EU, NASA, NAS, UNEP, WMO and the British government had dissenting scientific reports, and Watson played a role in the combined evaluation process. Based on the experience in the Ozone case, the IPCC has begun working on a unified reporting and science assessment to reach a consensus to provide the IPCC Summary for Policymakers. [44] There are several areas of connection between ozone depletion and the science of global warming: Radative coercion from various greenhouse gases and other sources is expected to cool the stratosphere from the same CO_2 Radiative compulsion that produces global warming. [144] This cooling is also expected to lead to a relative increase in ozone (O_3) depletion in the polar region and the frequency of ozone holes. [145] Conversely, ozone depletion represents a radiative compulsion of the climate system. It has two counter effects: reduced ozone causes the stratosphere to absorb less solar radiation, thereby cooling the stratosphere when heating the troposphere; The resulting cold stratosphere emits less long wave radiation downwards, thereby cooling the troposphere. In general, cooling prevails; Ipcc In the last two decades, stratospheric O_3 losses have caused a negative icing of the surface-troposphere system[24] by approximately 0.15 watts ± (W/m^2) per ±. [107] One of the strongest estimates of the greenhouse effect is that the stratosphere will cool down. [144] Although this cooling has been observed, it is not insignificant to separate the effects of changes in the concentration of greenhouse gases and ozone depletion, as both will lead to cooling. However, this can be done with numerical stratospheric modeling. Results from the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory show that greenhouse gases over 20 km dominate cooling. [146] As stated in the 'Public Policy', chemicals that consume the ozone layer are usually greenhouse gases. Increases in concentrations of these chemicals produced 0.34 ± 0.03 W/m^2 radative coercion, while increases in concentrations of well mixed greenhouse gases correspond to about 14 percent of total radiative coercion. [107] It takes decades for the process to be modeled, measured, examined, documented in the design of theories and tests, broad acceptance and ultimately becoming the dominant paradigm. Several theories about the destruction of oson were published in the 1980s and late 1990s and are currently being investigated. Dr. Drew Schindell, and Dr. Paul Newman, NASA Goddard, proposed a theory in the late 1990s, using computational modeling methods to model ozone destruction, which accounted for 78 percent of ozone. Further improvement of this model destroyed 89 percent of the ozone, but the estimated retrieval of the ozone hole increased from 75 years to 150 years. (An important part of this model is the lack of stratospheric flight due to the depletion of fossil fuels.) In 2019, NASA reported that there is no significant relationship between the size of the ozone hole and climate change. [6] Because CFC molecules are heavier than air (nitrogen or oxygen), CFC molecules are believed to be unable to reach the stratosphere in significant amounts. [147] However, atmospheric gases are not sorted by weight; Wind Forces can completely mix gases in the atmosphere. Lighter CFCs are evenly distributed throughout the turbosphere and reach the upper atmosphere,[148] but some heavy CFCs are not evenly distributed. [149] Another misconception of stratospheric chlorine is that natural tropospheric chlorine sources are generally four to five times larger than man-made sources. While this statement is absolutely correct, tropospheric chlorine is irrelevant; it is stratospheric chlorine that affects the depletion of the ozone layer. Chlorine from ocean spray is soluble and thus washed with precipitation before reaching the stratosphere. CFCs, by contrast, are insoluble and long-lasting, allowing them to reach In the lower atmosphere, there is much more chlorine than HCl without spraying salt from CFCs and related haloalcanes, and halocarbons in the stratosphere are dominant. [150] Methyl chloride, one of only these halocarbons, has a mostly natural source[151] and about 20 percent of the chlorine in the stratosphere is responsible; The remaining 80 percent come from man-made sources. Very severe volcanic eruptions can inject HCl into the stratosphere, but researchers[152] have shown that the contribution is not significant according to cfcs. A similar erroneous claim that the volcanic feather-soluble halogen compounds of Mount Erebus on Ross Island are a major contributor to the Antarctic ozone hole in Antarctica. [152] However, a 2015 study[153] showed that the role of Erebus Volcano in the depletion of Antarctic ozone was probably underestimated. Based on NCEP/NCAR reanalysis data over the past 35 years and using the NOAA HYSPLIT orbital model, researchers showed that Erebus volcano gas emissions (including hydrogen chloride (HCl)) can reach the Antarctic stratosphere through high latitude cyclones and then the polar thinging. Depending on erebus volcano activity, the additional annual HCl mass entering the Erebus stratosphere varies between 1.0 and 14.3 kt. The first observation g.M.B. Dobson stated that when the first spring ozone levels in Antarctica over Halley Bay were first measured in 1956, they were surprised to find that there were about 150 DU below spring Arctic levels of ~320 DU, or ~450 DU. These were the only known Antarctic ozone values at the time. What Dobson explains is actually the basis on which the ozone hole is measured: the actual ozone hole values range from 150-100 DU. [154] The discrepancy between the Arctic and Antarctica cited by Dobson was primarily a matter of timing: ozone levels rose smoothly during the Arctic spring period, peaking in April, whereas they remained approximately constant in Antarctica in early spring and suddenly rose when the polar vortex broke in November. The behavior seen in the Antarctic ozone hole is completely different. Instead of staying steady, early spring ozone levels suddenly drop as low as 50 percent from already low winter values, and normal values are not reached again until December. [155] Location of the hole Some people thought the ozone hole should be above the sources of CFCs. However, CFCs are well mixed globally in the troposphere and stratosphere. The reason for the formation of an ozone hole over Antarctica is not because more CFC is concentrated, but because low temperatures help create polar saltospheric clouds. [156] In fact, as with central Asia, there are significant and localized ozone holes in other parts of the world. [157] World Ozone Day in 1994, the United Nations General Assembly declared September 16 as International Day of Protection. The signing of the Montreal Protocol in 1987[159] commemorates the ozone layer, or Earth Ozone Day[158]. [160] We also see the Arctic Ecology portal Environment portal Global warming portal

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