DOWNLOAD PDF CLIMATE CHANGE AND STRATOSPHERIC OZONE DEPLETION

Chapter 1 : Ozone depletion and climate change - calendrierdelascience.com

Finally, these two issues are similar in that ozone depletion provides a smaller-scale analogue for the kinds of political and economic changes we will have to make to address climate change: Unintended chemical side effects of our economy posed a serious threat to all species, including our own.

In the last decade scientists, policy makers, and the general public have focused increasing concern on ozone depletion in the upper atmosphere and on global climate change. These two problems are closely interrelated and both are of truly global scale. Two primary areas link the issue of stratospheric ozone depletion to global climate change: Atmospheric processes establish a linkage through the dual roles of certain trace gases in promoting global warming and in depleting the ozone layer. The primary radiatively active trace gases are carbon dioxide, nitrous oxide, chlorofluorocarbons, methane, and tropospheric ozone. At increased levels they can contribute to global climate change. This diffuse layer of ozone in the stratosphere protects life on earth from harmful solar radiation. The second mode of interaction revolves around various ecological processes. Physical, chemical, and biological activities of plants and animals are affected directly by global climate change and by increased ultraviolet radiation resulting from depletion of stratospheric ozone. The purposes of this paper are to: This is known as the ultraviolet-B or UV-B range and it can be damaging to humans, biological organisms, and man-made materials. These gases accumulate in the lower atmosphere troposphere and then gradually migrate upward into the stratosphere where they contribute to depletion of stratospheric ozone. The atmospheric and chemical processes involved in the destruction of ozone are extremely complex and are reviewed elsewhere [e. Short wavelength radiation hitting the stratosphere causes a breakup of the chlorofluorocarbons releasing the chlorine radicals see figure 1. A chlorine radical destroys stratospheric ozone through a catalytic cycle producing oxygen molecules. The catalytic cycle of a chlorine radical breaking down ozone into oxygen molecules. Less ozone in the stratosphere will result in a greater transmission of ultraviolet radiation to the surface of the earth, causing detrimental effects. Because of the long atmospheric lifetimes of CFCs and halons, scientists expect stratospheric ozone to continue to decrease into the middle of the next century even if emissions are curtailed worldwide [2]. Trace gases affecting ozone concentrations and global climate change. Plastic Foams, Sterilants ,0 1. Currently, the primary focus of regulations and mitigation options are on CFCs and halons, as depicted in the Montreal Protocol [3]. The treaty document was officially ratified in December ; regulatory provisions become effective in July The agreement calls for a freeze of CFC production at levels by , a 20 percent decrease in production by , and an additional 30 percent decrease by Several recent national and international work group reports detailed discussions of the growing concern about stratospheric ozone depletion and assessment of scientific bases underlying such concern [e. A report by the Ozone Trends Panel has also highlighted the issue of stratospheric ozone depletion [6]. They do, however, absorb the long wavelength radiation that is radiated back from the surface of the earth, resulting in the greenhouse effect. In addition to CFCs, other gases contribute to the greenhouse effect, including: The effects of these gases on global warming is cumulative because each blocks different wavelength radiation. Their concentrations have been increasing over time, some more dramatically than others. This point is particularly important because of their relatively long atmospheric lifetimes, especially CFCs, halons and nitrous oxide. The release of CFCs and other chlorine-containing compounds decreased initially in the s as a result of regulatory action to ban selected, non- essential CFC compounds used as aerosol propellants. This regulation was enacted in several countries, including the United States. Currently, CFC production and consumption are increasing due at least in part to the involvement of newly industrialized and lesser developed countries in CFC use. In addition to breaking down ozone through the action of chlorine radicals, chlorofluorocarbons contribute to the greenhouse effect. Estimates put the CFC contribution to global temperature change at percent, although under the Montreal Protocol it would be reduced to percent. Nitrous oxide in the atmosphere originates from both natural and man-made sources, including many bacterial processes involved in the nitrification or denitrification cycles. Recently, nitrous oxide has been increasing at a rate of V about 0. In the atmosphere N20 is partly converted into nitrogen oxides NOx. Nitrous oxide N20 plays a role in both ozone depletion and global climate change. The N20 functions as a greenhouse gas contributing to global warming. Converted to nitrogen oxides NOx it destroys stratospheric ozone in a catalytic cycle similar to that of chlorine radicals. On the other hand, nitrogen oxides can serve as a temporary sink for the ozone depleting chlorine monoxide CIO , so the net effect is uncertain. NOx also is a precursor to acid deposition. The concentration of C02 has been increasing in recent years by an average of about 0. Carbon dioxide links the issue of stratospheric ozone depletion to that of the global climate change issue primarily because of its role as a greenhouse gas. As such, it will absorb solar radiation being radiated from the surface of the earth and re-radiate it in all directions increasing the global warming. Because it is a greenhouse gas C02 modifies the temperature structure of the atmosphere, cooling the stratosphere Less ozone is destroyed if the stratosphere is cooler, so the effect of C02 acting alone is to decrease ozone depletion in the stratosphere. Resulting from both natural and man-made processes, methane is involved in several important reactions in the atmosphere. Through its effect on the amounts of water vapor in the stratosphere methane can lead to destruction of stratospheric ozone. Water droplets may act as a surface upon which the reactions that destroy ozone occur. The increase or decrease of ozone depletion will depend upon where the water vapor is produced. Ozone depletion will increase if water vapor increases in the stratosphere. A further effect of methane occurs in the troposphere. Here, when methane is oxidized, it will produce an increase in the amount of tropospheric ozone. This reaction occurs in the presence of nitrogen oxide. Natural sources of methane include natural wetlands, arctic tundra, agricultural crops such as rice paddies, and ruminate animals. Man-made sources of CH4 include the production of fossil fuels such as natural gas and oil, and cement production. The natural processes contribute about half of the total methane production. Carbon monoxide is not a radiatively important trace gas, but it is involved indirectly in both stratospheric ozone destruction and global warming. Carbon monoxide controls the concentration of the hydroxy1 radical OH in the troposphere, which has a direct effect on the concentration of methane. The concentration of methane, as described earlier, plays a role in the amount of tropospheric ozone as well as stratospheric ozone. Methane is also a very important contributor to the greenhouse effect. Based on current scenarios, the stratospheric component of the total ozone column is calculated to decrease over time, whereas the tropospheric constituents of the total ozone column will increase. Whether or not there will be an overall increase in the level of ultraviolet radiation reaching the surface of the earth is still uncertain. Changes in the concentration and altitude of ozone will play a major role in altering temperature and atmospheric processes affecting current climate and perhaps add to long-term global climate change. These conditions affect regional air quality. Tropospheric ozone formation takes place in the presence of nitrogen oxide. In addition, hydrogen peroxide H is produced, which is a strong oxidant and a catalyst in the production of sulfuric acid from sulfur dioxide. These two processes illustrate the linkage between stratospheric ozone depletion and acid deposition. Sulfur dioxide and nitrogen oxides are the two major precursors to acid deposition. Trace gases affecting ozone also contribute to global climate change. Any efforts by humans to address the potential problems in either area will influence the other. If global warming were to begin, efforts to address the rise in greenhouse gases could increase ozone depletion. Restraints imposed on the buildup of carbon dioxide, methane, and nitrous oxide to control their contribution to global warming, might reduce their role as moderators of potential ozone depletion in high CFC emission scenarios [7]. Scientists have identified many potentially serious effects on the environment and on human health from increased exposure to UV-B radiation. These include damage to: Changes associated with an altered global climate, such as increased C02 levels, interact with the effects of UV-B radiation. In assessing the impact of increased exposure of crops and terrestrial ecosystems to UV-B radiation it must be recognized that existing knowledge is in many ways deficient. The effects of enhanced levels of UV-B radiation have been studied in species from only a few representatives of the major terrestrial ecosystems. We derive most of our knowledge from studies focused upon agricultural crops and conducted at mid- latitudes. Despite uncertainties due to the complexities of field experiments, the data presently available suggest that plant photosynthesis is vulnerable to increased levels of solar UV-B radiation [1]. Unlike drought or other geographically isolated stresses, stratospheric ozone depletion would affect all areas of the world, including ecosystems whose UV-B sensitivity has not been investigated. Less photosynthesis decreases the amount of C02 fixed by plants and exacerbates the rise in C02 levels. Higher C02 may lead to global warming. This shows a direct link from an effect of stratospheric ozone depletion through terrestrial ecosystems to climate change. Increased levels of UV-B radiation also may affect forest productivity. Only limited data are available on coniferous species, but about one-half of the species of seedlings studied were adversely affected by UV-B radiation [9]. Existing data also suggest that increased UV-B radiation will modify the distribution and abundance of plants. Even small changes in competitive balance over a period of time can result in large changes in community structure and composition [10]. Current evidence indicates that ambient solar UV-B radiation is an important limiting ecological factor in marine ecosystems. Even small increases of UV-B exposure could result in significant ecosystem changes [11]. In marine plant communities a change in species composition rather than a decrease in net production would be the probable result of enhanced UV-B exposure [12]. A change in community composition at the base of food webs may produce instabilities within ecosystems that likely would affect higher trophic levels [13]. Inhibition of marine microbial activity by increasing UV-B radiation could have important consequences for several global biogeochemical cycles. Bacterial activity in the oceans provides probably the most important global source of CH3I and CH3C1 the only significant natural source of chlorine to the stratosphere. Microorganisms in aquatic ecosystems produce large quantities of methane and nitrous oxide. Chemical and photochemical oxidation of natural organic matter in water bodies produces carbon monoxide. Enhanced UV-B radiation, resulting from stratospheric ozone depletion, can alter these processes and affect the levels of the various greenhouse gases in the atmosphere. Depletion of the ozone layer, resulting in large part from CFCs in the stratosphere, leads to increased UV-B radiation.

Chapter 2 : Linkage Between Climate Change and Stratospheric Ozone Depletion

Ozone depletion and climate change, or Ozone hole and global warming in more popular terms, are environmental challenges whose connections have been explored and which have been compared and contrasted, for example in terms of global regulation, in various studies and books.

NASA Earth Observatory Human activities cause ozone depletion and global warming Ozone O3 depletion does not cause global warming, but both of these environmental problems have a common cause: Global warming is caused primarily by putting too much carbon dioxide into the atmosphere when coal, oil, and natural gas are burned to generate electricity or to run our cars. Carbon dioxide spreads around the planet like a blanket, and is one of the main gases responsible for the absorption of infrared radiation felt as heat , which comprises the bulk of solar energy. Ozone depletion occurs when chlorofluorocarbons CFCs and halonsâ€"gases formerly found in aerosol spray cans and refrigerantsâ€"are released into the atmosphere see details below. How ozone works How ozone is distributed in the atmosphere. NOAA The sun emits electromagnetic radiation at different wavelengths, meaning energy at different intensities. The atmosphere acts like a multi-layer shield that protects Earth from dangerous solar radiation. Ozone is found in two different parts of our atmosphere. It is found in the lower atmosphere troposphere and has nothing to do with the "ozone hole. UV rays cannot be seen or felt, but they are very powerful and change the chemical structure of molecules. UV radiation plays a small role in global warming because its quantity is not enough to cause the excess heat trapped in the atmosphere. UV radiation represents a small percentage of the energy from the sun, and is not highly absorbed or scattered in the atmosphereâ€"especially when compared with other wavelengths, like infrared. But, ozone depletion is also concerning because it directly impacts the health of humans, and other living organisms. The ozone hole The ozone hole. Although ozone is created primarily at tropical latitudes, large-scale air circulation patterns in the lower stratosphere move ozone toward the poles, where its concentration builds up. In addition to this global motion, strong winter polar vortices are also important to concentrating ozone at the poles. During the continuously dark polar winter, the air inside the polar vortices becomes extremely cold, a necessary condition for polar stratospheric cloud formation. Polar stratospheric clouds create the conditions for drastic ozone destruction, providing a surface for chlorine to change into ozone-destroying form. They generally last until the sun comes up in the spring. NASA In the s, scientists discovered that the ozone layer was thinning in the lower stratosphere, with particularly dramatic ozone lossâ€"known as the "ozone hole"â€"in the Antarctic spring September and October. These chemicals can remain in the atmosphere for decades to over a century. At the poles, CFCs attach to ice particles in clouds. When the sun comes out again in the polar spring, the ice particles melt, releasing the ozone-depleting molecules from the ice particle surfaces. Once released, these ozone-destroying molecules do their dirty work, breaking apart the molecular bonds in UV radiation-absorbing ozone. The Montreal Protocol Anniversary poster of the Vienna Convention for the Protection of the Ozone Layer , the first international cooperation effort to protect the ozone layer. United Nations Environmental Program. CFCs were commonly found in refrigerants, solvents, propellants, and foam-blowing agents before the Montreal Protocol was agreed on in the sâ€" an international commitment to phase out ozone-depleting chemicals that was universally ratified by all countries that participate in the UN. The Montreal Protocol set an important precedent but more needs to be done. It appears unlikely that the decrease in ozone-depleting substances alone will lead to the recovery of the stratospheric ozone layer to its pre concentration levels because of the competing and uncertain effects of further climate change. In a worrying development, after an extremely cold winter in early , for the first time the ozone reduction in the Arctic was comparable to that in the Antarctic. Stratospheric ozone also has natural processes that remove it from the atmosphere. Tiny sulfate particles aerosols blasted into the stratosphere by the volcanic eruption of Mount Pinatubo in caused measurable decreases in ozone for several years following the eruptions. Does global warming have an impact on the stratospheric ozone layer? Temperature change in both the lower stratosphere and the lower troposphere go in opposite directions--a telling sign of excess carbon dioxide in the troposphere. Since the s, there has been a trend of increasing warming of the lower atmosphere and a cooling of the upper atmosphere. This warming-cooling dynamic creates conditions that lead to ozone loss. Observations show that as greenhouse gases increase and result in heating in the lower atmosphere troposphere , a cooling is occurring in the upper atmosphere stratosphere. Carbon dioxide and other heat-trapping gases rise into the atmosphere and spread around the globe, like a blanket wrapping Earth. This blanket warms the surface of the Earth and protects it from the cold air above it. The increased concentrations of heat-trapping gases make the blanket uncomfortably thicker. The blanket also prevents heat from moving from the lower atmosphere to the stratosphere, cooling down the stratosphere as a result. In other words, heat-trapping gases contribute to creating the cooling conditions in the atmosphere that lead to ozone depletion. Greenhouse gases absorb heat at relatively low altitudes and warm the surface--but they have the opposite effect in higher altitudes because they prevent heat from rising. In a cooler stratosphere, ozone loss creates a cooling effect that results in further ozone depletion. UV radiation releases heat into the stratosphere when it reacts with ozone. With less ozone there is less heat released, amplifying the cooling in the lower stratosphere, and enhancing the formation of ozone-depleting polar stratospheric clouds, especially near the South Pole. July 27, We Need Your Support to Make Change Happen We can reduce global warming emissions and ensure communities have the resources they need to withstand the effects of climate changeâ€”but not without you. Your generous support helps develop science-based solutions for a healthy, safe, and sustainable future.

Chapter 3 : Ozone depletion - Wikipedia

Well before the expected stratospheric ozone layer recovery date of , ozone's effects on climate may become the main driver of ozone loss in the stratosphere. As a result, ozone recovery may not be complete until or

Sir Robert Bob Watson played an important role in both cases There are both links and major differences between ozone depletion and global warming and the way the two challenges have been handled. While in the case of atmospheric ozone depletion, in a situation of high uncertainty and against strong resistance, climate change regulation attempts at the international level such as the Kyoto Protocol have failed to reduce global emissions. US manufacturer DuPont acted more quickly than their European counterparts. They pointed out that the goal of the IPCC is to fairly represent the complete range of credible scientific opinion and if possible a consensus view. Three years later the report made an impact with the assessment of the state of the art in climate research, an assessment of the threat of climate change itself as well as suggestions for clear emissions reduction targets, even though he argues there was no consensus, and attributed the success of the report to strong precautionary action, and that no scientific outsiders or climate change skeptics were involved. Public opinion on climate change The two atmospheric problems have achieved significantly different levels of understanding by the public, including both the basic science and policy issues. Americans voluntarily switched away from aerosol sprays before legislation was enforced, while climate change has failed in achieving a broader scientific comprehension and in raising comparable concern. This was not the case with global warming. Sheldon Ungar, a Canadian sociologist, assumes that while the quantity of specialized knowledge is exploding, in contrast scientific ignorance among lay people is the norm and even increasing. Public opinion failed to tie climate change to concrete events which could be used as a threshold or beacon to signify immediate danger. The scientific assessment of the ozone problem also had large uncertainties; both the ozone content of the upper atmosphere and its depletion are complicated to measure and the link between ozone depletion and rates of enhanced skin cancer is rather weak. But the metaphors used in the discussion ozone shield, ozone hole resonated better with lay people and their concerns. It is these pre-scientific bridging metaphors built around the penetration of a deteriorating shield that render the ozone problem relatively simple. That the ozone threat can be linked with Darth Vader means that it is encompassed in common sense understandings that are deeply ingrained and widely shared. The fate of celebrities like President Ronald Reagan , who had skin cancer removal from his nose in and , was also of high importance. Economics of global warming Cass Sunstein and others have compared the differing approach of the United States to the Montreal Protocol, which it accepted, and the Kyoto Protocol, which it rejected. A citizen boycott of spray cans gained importance in parallel. The EU shifted its position after Germany, which also has a large chemical industry, gave up its defence of the CFC industry [4] and started supporting moves towards regulation. In the case of Kyoto, then secretary of the environment Angela Merkel , prevented a possible failure by suggesting to use as starting date for emission reduction. In so far the demise of the Eastern European heavy industry allowed for a high commitment, but actual emissions kept on growing on a global scale.

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Chapter 4 : Ozone depletion and climate change - Wikipedia

Ozone depletion and climate change The climate system involves the atmosphere - specifically processes within the troposphere, such as air circulation patterns - land surfaces and oceans. The ozone layer is found in the stratosphere, which is the layer of the atmosphere immediately above the troposphere.

Page 3 Share Cite Suggested Citation: The National Academies Press. Introduction Two important climatic issues-stratospheric ozone depletion and greenhouse gas increase-and the apparent connection between them led to the holding of this symposium. Theory predicts that ozone depletion should be occurring as a result of chIorofluorocarbons and haloes in the stratosphere. Recent measurements confirm that such depletion is taking place on a global scale and is especially pro- nounced in the antarctic stratosphere. Global tropospheric warming due to increasing greenhouse gases has been an important climatic issue for many years, and several symposia and workshops have pre- viously been held on this topic. However, recent data have made it increasingly apparent that the projected increase in greenhouse gases and the associates! Thus, the two issues are inextricably entwined and form part of the larger global change issue that recognizes that essentially all components of the earth-atmosphere-ocean-biosphere-cryosphere system interact with and affect one another, often in ways that are currently not well understood. This symposium was primarily concerned with the linkages be- tween ozone depletion and increasing greenhouse gases and with their combined effect in causing climate change to occur on a global scale. Some of the questions and answers that followed the presentations have been included when they highlight noteworthy points that were not covered in the presentation itself. The request by the National Climate Program Office for a symposium on the above related issues is included as Appendix A, and the symposium agenda and participants are given in Appendix B. Appendix C is a glossary of special terms and abbreviations. The first presentation, by William C. Clark, provides an overview of the global change issue and indicates the role of the symposium in furthering the goals of that larger effort. Albritton discusses the observational ant! In his paper, F. Sherwood Rowland discusses the long-term out- look for stratospheric halocarbon concentrations and the associated outlook for ozone concentrations. He also presents evidence of recent stratospheric ozone depletion in the Northern Hemisphere, espe- cially in winter. Molina describes the specific heterogeneous chemical processes, believed to occur in the polar stratosphere, that result in the efficient destruction of ozone by free chlorine atoms and chlorine oxides. Anderson also presents additional evidence that shows why heterogeneous processes are especially efficient when ice clouds form in the polar stratospheric regions. MahIman reviews the combined effect of trace gases on changing stratospheric temperatures and circulation. MahIman indi- cates that these stratospheric changes will feed back on the behavior of the trace gases and on the concentration of ozone, necessitat- ing the use of dynamic modeling in order to fully understand and accurately predict the changes that will occur. Harriss indicates that the extensive peat bogs and marshlands of the arctic slope are likely to be prime sources of increased atmospheric methane as the climate warms, pro- viding a positive feedback for tropospheric warning and affecting stratospheric ozone distribution. Trenberth reviews the evidence for global temperature trends, including both tropospheric warming and stratospheric cool- ing. Trenberth notes that the short duration of reliable stratospheric records along with other data problems makes it especially difficult to establish unambiguous temperature trends in the stratosphere. In the last paper, Robert E. Dickinson reviews the progress made with - general circulation models in predicting the likely climatic changes engendered by increasing greenhouse gases and indicates those as- pects of the climate system that are critical and in need of further mode! In summary, the Joint Symposium on Ozone Depletion, Green- house Gases, and Climate Change reviewed the magnitude and causes of stratospheric ozone depletion and examined the connections that exist between this problem and the impending climate warming due to increasing greenhouse gases. The presentations of these proceed- ings indicate that the connections are real and important and that the stratospheric ozone depletion and tropospheric greenhouse warm- ing problems must be studied as parts of an interactive global system rather than as more or less unconnected events.

Chapter 5 : WHO | Climate change and human health - risks and responses. Summary.

In summary, the Joint Symposium on Ozone Depletion, Green- house Gases, and Climate Change reviewed the magnitude and causes of stratospheric ozone depletion and examined the connections that exist between this problem and the impending climate warming due to increasing greenhouse gases.

Ozone is formed in the stratosphere when oxygen molecules photodissociate after intaking ultraviolet photons. This converts a single O 2 into two atomic oxygen radicals. The atomic oxygen radicals then combine with separate O 2 molecules to create two O 3 molecules. These ozone molecules absorb ultraviolet UV light, following which ozone splits into a molecule of O 2 and an oxygen atom. The oxygen atom then joins up with an oxygen molecule to regenerate ozone. This is a continuing process that terminates when an oxygen atom recombines with an ozone molecule to make two O 2 molecules. The dot is a notation to indicate that each species has an unpaired electron and is thus extremely reactive. These elements are found in stable organic compounds, especially chlorofluorocarbons , which can travel to the stratosphere without being destroyed in the troposphere due to their low reactivity. Once in the stratosphere, the Cl and Br atoms are released from the parent compounds by the action of ultraviolet light, e. Cl and Br atoms destroy ozone molecules through a variety of catalytic cycles. In the simplest example of such a cycle, [5] a chlorine atom reacts with an ozone molecule O 3 , taking an oxygen atom to form chlorine monoxide ClO and leaving an oxygen molecule O 2. The ClO can react with a second molecule of ozone, releasing the chlorine atom and yielding two molecules of oxygen. The chemical shorthand for these gas-phase reactions is: More complicated mechanisms have also been discovered that lead to ozone destruction in the lower stratosphere. The ozone cycle Global monthly average total ozone amount Lowest value of ozone measured by TOMS each year in the ozone hole A single chlorine atom would continuously destroy ozone thus a catalyst for up to two years the time scale for transport back down to the troposphere were it not for reactions that remove them from this cycle by forming reservoir species such as hydrogen chloride HCl and chlorine nitrate ClONO 2. Bromine is even more efficient than chlorine at destroying ozone on a per atom basis, but there is much less bromine in the atmosphere at present. Both chlorine and bromine contribute significantly to overall ozone depletion. Laboratory studies have also shown that fluorine and iodine atoms participate in analogous catalytic cycles. A single chlorine atom is able to react with an average of , ozone molecules before it is removed from the catalytic cycle. This is normally expressed in Dobson units ; abbreviated as "DU". The most prominent decrease in ozone has been in the lower stratosphere. Marked decreases in column ozone in the Antarctic spring and early summer compared to the early s and before have been observed using instruments such as the Total Ozone Mapping Spectrometer TOMS. Antarctic total column ozone in September and October have continued to be 40â€”50 percent lower than pre-ozone-hole values since the s. It is expected to recover around The greatest Arctic declines are in the winter and spring, reaching up to 30 percent when the stratosphere is coldest. Reactions that take place on polar stratospheric clouds PSCs play an important role in enhancing ozone depletion. This is why ozone holes first formed, and are deeper, over Antarctica. Early models failed to take PSCs into account and predicted a gradual global depletion, which is why the sudden Antarctic ozone hole was such a surprise to many scientists. Total column ozone declined below pre values between and for mid-latitudes. In the northern mid-latitudes, it then increased from the minimum value by about two percent from to as regulations took effect and the amount of chlorine in the stratosphere decreased. There are no significant trends in the tropics, largely because halogen-containing compounds have not had time to break down and release chlorine and bromine atoms at tropical latitudes. Pinotubo in the Philippines. Some stratospheric cooling is also predicted from increases in greenhouse gases such as CO 2 and CFCs themselves; however, the ozone-induced cooling appears to be dominant. The total amount of effective halogens chlorine and bromine in the stratosphere can be calculated and are known as the equivalent effective stratospheric chlorine EESC. They were used in air conditioning and cooling units, as aerosol spray propellants prior to the s, and in the cleaning processes of delicate electronic equipment. They also occur as by-products of some chemical processes. No significant natural sources have ever been identified for these compoundsâ€"their presence in the atmosphere is due almost entirely to human manufacture. As mentioned above, when such ozone-depleting chemicals reach the stratosphere, they are dissociated by ultraviolet light to release chlorine atoms. The chlorine atoms act as a catalyst , and each can break down tens of thousands of ozone molecules before being removed from the stratosphere. Given the longevity of CFC molecules, recovery times are measured in decades. It is calculated that a CFC molecule takes an average of about five to seven years to go from the ground level up to the upper atmosphere, and it can stay there for about a century, destroying up to one hundred thousand ozone molecules during that time. Its source remains a mystery, but illegal manufacturing is suspected by some. CFCa seems to have been accumulating unabated since Between and , emissions of the gas jumped by 45 percent. These complex chemistry transport models e. They identify key chemical reactions and transport processes that bring CFC photolysis products into contact with ozone. Ozone hole and its causes[edit] Ozone hole in North America during abnormally warm reducing ozone depletion and abnormally cold resulting in increased seasonal depletion. NASA [22] The Antarctic ozone hole is an area of the Antarctic stratosphere in which the recent ozone levels have dropped to as low as 33 percent of their pre values. The ozone hole occurs during the Antarctic spring, from September to early December, as strong westerly winds start to circulate around the continent and create an atmospheric container. Within this polar vortex , over 50 percent of the lower stratospheric ozone is destroyed during the Antarctic spring. In the presence of UV light, these gases dissociate, releasing chlorine atoms, which then go on to catalyze ozone destruction. The Cl-catalyzed ozone depletion can take place in the gas phase, but it is dramatically enhanced in the presence of polar stratospheric clouds PSCs. Polar winters are dark, consisting of three months without solar radiation sunlight. The lack of sunlight contributes to a decrease in temperature and the polar vortex traps and chills air. These low temperatures form cloud particles. There are three types of PSC cloudsâ€"nitric acid trihydrate clouds, slowly cooling water-ice clouds, and rapid cooling water-ice nacerous cloudsâ€"provide surfaces for chemical reactions whose products will, in the spring lead to ozone destruction. The key observation is that, ordinarily, most of the chlorine in the stratosphere resides in "reservoir" compounds, primarily chlorine nitrate ClONO 2 as well as stable end products such as HCl. The formation of end products essentially remove Cl from the ozone depletion process. The process by which the clouds remove NO 2 from the stratosphere by converting it to nitric acid in the PSC particles, which then are lost by sedimentation is called denitrification. The role of sunlight in ozone depletion is the reason why the Antarctic ozone depletion is greatest during spring. During winter, even though PSCs are at their most abundant, there is no light over the pole to drive chemical reactions. During the spring, however, the sun comes out, providing energy to drive photochemical reactions and melt the polar stratospheric clouds, releasing considerable ClO, which drives the hole mechanism. Further warming temperatures near the end of spring break up the vortex around mid-December. As warm, ozone and NO 2-rich air flows in from lower latitudes, the PSCs are destroyed, the enhanced ozone depletion process shuts down, and the ozone hole closes. The limited scientific knowledge of the public led to a confusion with global warming [29] or the perception of global warming as a subset of the "ozone hole". The "ozone hole" is more of a depression, less "a hole in the windshield". The ozone does not disappear through the layer, nor is there a uniform "thinning" of the ozone layer. However they resonated better with non-scientists and their concerns. Not only on the policy level, ozone regulation compared to climate change fared much better in public opinion. Americans voluntarily switched away from aerosol sprays before legislation was enforced, while climate change failed to achieve comparable concern and public action. The especially rapid ozone depletion in Antarctica had previously been dismissed as a measurement error. Many have worried that ozone holes might start appearing over other areas of the globe, though to date the only other large-scale depletion is a smaller ozone "dimple" observed during the Arctic spring around the North Pole. Ozone at middle latitudes has declined, but by a much smaller extent a decrease of about 4â€"5 percent. If stratospheric conditions become more severe cooler temperatures, more clouds, more active chlorine , global ozone may decrease at a greater pace. Standard global warming theory predicts that the stratosphere will cool. Decreases in the ozone level of up to 10 percent have been reported in New Zealand in the month following the breakup of the Antarctic ozone hole, [37] with ultraviolet-B radiation intensities increasing by more than 15 percent since the s. This was the reason for the Montreal Protocol. Although decreases in stratospheric ozone are well-tied to CFCs and to increases in surface UVB, there is no direct observational evidence linking ozone depletion to higher incidence of skin cancer and eye damage in human beings. This is partly because UVA , which has also been implicated in some forms of skin cancer, is not absorbed by ozone, and because it is nearly impossible to control statistics for lifestyle changes over time. The amount of UVB radiation that penetrates through the ozone layer decreases exponentially with the slant-path thickness and density of the layer. The report concluded that depleted ozone levels around the mid-latitudes of the planet are already endangering large populations in these areas. Biological effects[edit] The main public concern regarding the ozone hole has been the effects of increased surface UV radiation on human health. So far, ozone depletion in most locations has been typically a few percent and, as noted above, no direct evidence of health damage is available in most latitudes. If the high levels of depletion seen in the ozone hole were to be common across the globe, the effects could be substantially more dramatic. As the ozone hole over Antarctica has in some instances grown so large as 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. In addition, increased surface UV leads to increased tropospheric ozone, which is a health risk to humans. Basal and squamous cell carcinomas[edit] The most common forms of skin cancer in humans, basal and squamous cell carcinomas, have been strongly linked to UVB exposure. The mechanism by which UVB induces these cancers is well understoodâ€"absorption of UVB radiation causes the pyrimidine bases in the DNA molecule to form dimers , resulting in transcription errors when the DNA replicates. These cancers are relatively mild and rarely fatal, although the treatment of squamous cell carcinoma sometimes requires extensive reconstructive surgery. By combining epidemiological data with results of animal studies, scientists have estimated that every one percent decrease in long-term stratospheric ozone would increase the incidence of these cancers by two percent. The relationship between malignant melanoma and ultraviolet exposure is not yet fully understood, but it appears that both UVB and UVA are involved. Because of this uncertainty, it is difficult to estimate the effect of ozone depletion on melanoma incidence. 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. A detailed assessment of ocular exposure to UVB was carried out in a study on Chesapeake Bay Watermen, where increases in average annual ocular exposure were associated with increasing risk of cortical opacity. Based on these results, ozone depletion is predicted to cause hundreds of thousands of additional cataracts by Ground-level ozone is generally recognized to be 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 respiratory difficulties. At this time, ozone at ground level is produced mainly by the action of UV radiation on combustion gases from vehicle exhausts. Thus, higher UVB exposure raises human vitamin D in those deficient in it.

Chapter 6 : Health and Environmental Effects of Ozone Layer Depletion | Ozone Layer Protection | US EPA

Carbon dioxide links the issue of stratospheric ozone depletion to that of the global climate change issue primarily because of its role as a greenhouse gas. As such, it will absorb solar radiation being radiated from the surface of the earth and re-radiate it in all directions increasing the global warming.

Temperature, humidity, winds, and the presence of other chemicals in the atmosphere influence ozone formation, and the presence of ozone, in turn, affects those atmospheric constituents. Interactions between ozone and climate have been subjects of discussion ever since the early s when scientists first suggested that human-produced chemicals could destroy our ozone shield in the upper atmosphere. Today, some scientists are predicting the stratospheric ozone layer will recover to ozone levels by the year These scientists say we can expect recovery by that time because most nations have been abiding by international agreements to phase out production of ozone-depleting chemicals such as chlorofluorocarbons CFCs and halons. But the atmosphere continues to surprise us, and some atmospheric scientists recently demonstrated a new spin on the ozone recovery story that may change its ending. As a result, ozone recovery may not be complete until or The more ozone in a given parcel of air, the more heat it retains. Consequently, decreased ozone in the stratosphere results in lower temperatures. This stratospheric cooling has taken place at the same time that greenhouse gas amounts in the lower atmosphere troposphere have risen. The two phenomena may be linked. I started to ask how cold the stratosphere might get because of increasing amounts of greenhouse gases. I was wondering whether or not the cooling in the stratosphere would be rapid enough that more ozone depletion would take place than we had previously calculated. Would the cooling be so fast that even more ozone depletion would occur before the impact of international agreements to limit ozone had time to take effect? The more ozone destruction in the stratosphere, the colder it would get just because there was less ozone. And the colder it would get, the more ozone depletion would occur. The deepest ozone losses over both the Arctic and the Antarctic result from special conditions that occur in the winter and early spring. As winter arrives, a vortex of winds develops around the pole and isolates the polar stratosphere. Chemical reactions on the surfaces of ice crystals in the clouds release active forms of CFCs. In spring, temperatures begin to rise, the ice evaporates, and the ozone layer starts to recover. The graph above shows total ozone and stratospheric temperatures over the Arctic since Changes in ozone amounts are closely linked to temperature, with colder temperatures resulting in more polar stratospheric clouds and lower ozone levels. Atmospheric motions drive the year-to-year temperature changes. The Arctic stratosphere cooled slightly since , but scientists are currently unsure of the cause. Future NASA missions, starting with the Aura satellite, will improve our understanding of the links between global climate change and ozone chemistry. Scientists running different kinds of global models are finding similar results. One reason may be that the presence of ozone itself generates heat, and ozone depletion cools the stratosphere. Another contributing factor to the cooling may be that rising amounts of greenhouse gases in the lower atmosphere troposphere are retaining heat that would normally warm the stratosphere. However, scientists hold varying degrees of conviction about the nature of the link between tropospheric warming and stratospheric cooling. It is possible that they may be interdependent only in a tenuous manner. We have only 20 years of full global coverage from satellites. Of course radiosonde goes back 40 years but that is not global coverage. The climate system is highly sensitive, especially to changes in the tropopause region. We need exact temperatures and ozone profiles at different altitudes and around the globe. In spite of large uncertainties that remain, scientists express a sense of accomplishment with their achievements so far. Atmospheric models show that the cooling influence of ozone depletion accounts very well for observed cooling winter-time temperature trends in the Antarctic, but not in the Arctic. Differences among regions make predictions about complex atmospheric chemistry problematic. The Arctic and Antarctic regions, where low stratospheric ozone amounts are of great concern, differ in significant ways. The complex topography of the high latitude Northern Hemisphere, with its distribution of land masses and oceans, makes the Arctic atmosphere more dynamic and variable. The Antarctic is colder than the Arctic. Antarctic winds form a relatively stable vortex for long periods of time, and the vortex allows temperatures of the air trapped within it to get extremely low. Shindell explains, "In the south, air masses just sit over the pole and get colder. High mountains and the contrast between large continental landmasses and open ocean in the Northern Hemisphere disturb the air over the Arctic, preventing the formation of a stable circulation pattern. In part, it is the lack of a stable "polar vortex" that prevents the Arctic from experiencing the extremely cold temperatures and dramatic ozone loss seen above Antarctica. In spite of this, large ozone losses occurred in the Arctic during the last several years. Photograph courtesy NOAA Photo Library Although dramatic ozone depletion did not occur in the Arctic in the s when it occurred in the Antarctic, times are changing. Very large ozone losses have occurred in the Arctic recently, especially in the late s. Ozone chemistry is very sensitive to temperature changes. Since temperatures in the Arctic stratosphere often come within a few degrees of the threshold for forming polar stratospheric clouds, further cooling of the stratosphere could cause these clouds to form more frequently and increase the severity of ozone losses. The Arctic may be changing in another way that differs from the Antarctic. With stratospheric cooling, the differences in temperature between the stratosphere and the troposphere are increasing. Differences in temperature creates winds, so stratospheric wind speeds have been increasing. Shindell says that from both observations and models, he has found increasing wind speeds not only at high altitudes but also near the surface. There are known chemical and physical aspects of ozone formation we can watch carefully as climate changes. Ozone forms in the troposphere by the action of sunlight on certain chemicals photochemistry. Chemicals participating in ozone formation include two groups of compounds: In general, an increase in temperature accelerates photochemical reaction rates. Scientists find a strong correlation between higher ozone levels and warmer days. With higher temperatures, we can expect a larger number of "bad ozone" days, when exercising regularly outdoors harms the lungs. However, ozone levels do not always increase with increases in temperature, such as when the ratio of VOCs to NOx is low. As the troposphere warms on a global scale, we can expect changes in ozone air quality. Generally speaking, warming temperatures will modify some but not all of the complex chemical reactions involved in ozone production in the troposphere such as those involving methane. Because of the short-lived nature of these chemical constituents and variations across space and time, the uncertainty is too large to make predictions. Scientists can only speculate about specific kinds of change, about the direction of change in a particular location, or about the magnitude of change in ozone amounts that they can attribute to climate. Some speculation involves VOC emissions from natural biological processes. Certain kinds of plants such as oak, citrus, cottonwood, and almost all fast-growing agriforest species emit significant quantities of VOCs. Higher temperatures of a warming climate encourage more plant growth, and therefore higher levels of VOCs in areas where VOC-emitting plants grow abundantly. Soil microbes also produce NOx. Soil microbial activity may also increase with warmer temperatures, leading to an increase in NOx emissions and a consequent increase in ozone amounts. A warming climate can lead to more water vapor in the lower atmosphere, which would tend to produce more ozone. But cloud cover can also diminish chemical reaction rates because of reduced sunlight and therefore lower rates of ozone formation. Monitoring and analyzing such interactions is the best way we can improve our predictive capabilities. Most of our electric power plants emit NOx. As energy demand and production rises, we can expect amounts of NOx emissions to increase, and consequently levels of ozone pollution to rise as well. Water vapor is also involved in climate change. A warmer atmosphere holds more water vapor, and more water vapor increases the potential for greater ozone formation. But more cloud cover, especially in the morning hours, could diminish reaction rates and thus lower rates of ozone formation. Understanding the interactions between ozone and climate change, and predicting the consequences of change requires enormous computing power, reliable observations, and robust diagnostic abilities.

Chapter 7 : Climate Change Impacts Linked to Ozone Depletion - IGSD

Ozone depletion and climate change are linked in a number of ways, but ozone depletion is not a major cause of climate change. Atmospheric ozone has two effects on the temperature balance of the Earth.

Page 32 Share Cite Suggested Citation: The National Academies Press. A later speaker, James Anderson, will expand on the role of chlorine in causing the hole to occur. This talk addresses two questions: As Daniel Albritton noted, the Montreal Protocol did not explicitly take the appearance of the hole into account. However, the occurrence of the hole at about that time served as a major driving force to get the Europeans to view ozone as a serious issue and to get them to the table. It is worth noting that the appearance of the ozone hole was an unexpected event in the sense that the models referred to by Albritton did not predict the hole. The ozone hole has made modelers realize that stratospheric modeling needs further work and has rekindled scientific interest in the problem of stratospheric ozone. The ozone over Antarctica had, by October , been reduced by more than 50 percent of its value Watson et al. Ott,,, I o cn. The ozone hole itself did not fully disappear until late November or early December, This long-lasting minimum may have had significant consequences for the ecosystems in the antarctic region. The solar elevation angle is comparatively low by October, when the hole was at its deepest, but is much higher in November, when the ultraviolet UV effect might be stronger at the surface. For , the measurements show little in the way of an ozone hole as late as August After that, the ozone hole developed rapidly, especially after September 5, so that by October 5, the ozone over the middle of Antarctica had dropped from Dob- son units DU to DU. The monthly average October mean of ozone decreased from about DU in to DU in over the middle of Antarctica. Two ozonesondes were obtained on October 6 and 9, , at the U. This station is located near the edge of the region of low ozone. On October 6, when the edge of the strongly depleted region was poleward of the Paimer station, the ozone showed a fairly normal vertical profile. Three days later, the edge of the chemically disturbed and depleted region moved northward past the station, and the profile then showed a decrease of around 95 percent between 15 and 20 km. Other ozonesonde data from the South Pole, McMurdo, and Halley Bay stations, stations that were continually in the polar vortex region of depletion, show an almost complete disappearance of ozone after October 5. Hence, the ozone hole was a continent-wide phenomenon extending out to around the latitude of the Palmer station, where a steep horizontal gradient of ozone exited. A series of Nimbus 7 Total Ozone Mapping Spectrometer TOMS satellite images shows some recovery of ozone in the antarc- tic hole by November 15, , but the ozone amount remained below DU over most of the continent Figure a,b. By November 29, the minimum had moved from the polar region to over the Weddell Sea, surrounded by a large region of less than DU. Shaded areas are regions of no data during the polar night. December 5, the hole had filled considerably, with a minimum of about DU located well out over the Weddell Sea not far from the southern tip of South America. The relatively high sun angle of November and December coupled with this shift in the location of the ozone minimum likely resulted in a significant UV impact on the aquatic ecosystem of that region. Further comparison of with earlier years indicates a pro- gressively more rapid decrease of ozone during September in the later years. This fact is in agreement with a chemical hypothesis that, as more chlorine is- added to the system, the rate of seasonal ozone decrease becomes greater. From to , the ozone curve flattened or increased slightly, consistent with increased solar output after that countered the effects of increasing trace gases. This is consistent with the concept that the antarctic ozone hole phenomenon causes a dilution effect throughout much of the Southern Hemisphere. We now turn to the question of what is causing the antarctic ozone hole. Within the vortex, temperatures become cold enough to form stratospheric ice crystals. The ice crystab then allow unusual chemical interactions among nitrogen, hydrogen, and chlorine atoms. The weight of observational evidence indicates that the chlorine is primarily responsible for the ozone hole. Without chlorine in the antarctic stratosphere, there would be no ozone hole. Here "hole" refers to a substantial reduction below the naturally occurring concentration of ozone over Antarctica. The relevant chemical reactions occur within the polar vortex. Below 15 km, there is considerably more exchange of air between the midIatitudes and the polar regions. Hence, it is easier to explain behavior above 15 km in terms of chemistry than below 15 km, where atmospheric dynamics has an important role. Behavior below 15 km is still largely unexplained and is a matter of active research. Period shown includes the formation of the ozone minimum in These included observations of chlorine dioxide by Susan Solomon, which served as a very good indicator of perturbed chlorine chemistry, as well as measurements of very low nitrogen dioxide, showing that the atmosphere appears to be denitrified. We flew a DC-8 all over the antarctic continent during a 6-week period. We used remote sensors looking upward to obtain total column measurements of a wide variety of gases. Period shown includes the breakup of the ozone minimum in We had a lidar instrument to look at both ozone and the aerosols. The ER-2 aircraft flew as-high as The data from this ensemble of instruments are being used to test the various hypotheses that have been proposed. These theories include the solar theory, whereby periodically the amount of nitrogen compounds is enhanced. These enhanced levels can catalytically destroy ozone in the lower stratosphere. This theory, if correct, implies that levels of oxides of nitrogen should be elevated; besides, the ozone hole should occur cyclically. The data showed that this theory is completely and utterly wrong. The oxides of nitrogen were measured as being unusually low. Some other theories that require an increase in nitrogen compounds are likewise incorrect. Another theory, advanced by K. Tung, requires a change from downward to upward motions over Antarctica in association with other circulation changes. If this is correct, one should see enhanced levels of tropospheric trace gases such as nitrous oxide and methane in the lower and middle stratosphere. Therefore, the Heidt measurements were critical for this purpose. The ER-2 aircraft could not climb higher than Therefore, many of the measurements were made close to the inside edge of the polar vortex. It would have been scientifically desirable to have flown higher and farther southward in the vortex. One of our first flights was made on August 23, Water vapor dropped from about 3 ppm outside the vortex to about half this value inside, indicating that the atmosphere inside the vortex was dehydrated. Ozone changes were only slight across the vortex boundary. However, the abundance of the chlorine monoxide radical ClO increased from about 10 parts per trillion by volume to about parts per trillion. The nitrogen compounds except for nitrous oxide dropped from 8 to 10 parts per billion by volume ppbv to only 1. Thus, the vortex atmosphere on this date was dehydrated, denitrified, and highly enriched in chlorine oxides, but with little effect on ozone levels. By the end of our mission on September 22, the polar vortex atmosphere was still dehydrated and denitrified, the chlorine oxides had increased to about 1 ppbv, and the ozone concentration had dropped to less than half of its value outside the vortex. Therefore, it appears that a significant amount of time, approximately 1 month, is required for the chlorine oxides to destroy ozone. The concentrations of bromine oxides within the vortex were in the range of 3 to 5 parts per trillion on all flights. WATSON play a major role in destroying stratospheric ozone by the ClO-ClO mechanism, the proposed ClO-BrO mechanism for destroying ozone is of relatively minor importance, accounting for less than 10 percent of the total ozone depletion. The DC-8 flew nearly to the South Pole and obtained many bulk column measurements. The chlorine nitrate results from the presence of both ClO and nitrogen dioxide; hence it maximizes near the vortex boundary, where ClO is increasing rapidly but nitrogen dioxide is decreasing rapidly. Calculations by Anderson show that ozone depletion at the and K isentropic surfaces between August 23 and September 22 can be almost entirely explained by the amount of ClO present if one assumes that the ClO-ClO mechanism is effective. A number of measurements were obtained of particles, ranging from sulfuric acid particles less than 0. These measurements tend to support the current hypothesis of how chlorine oxide concentrations become enhanced in the polar stratosphere. Measurements of nitrous oxide and methane obtained at an al- titude of about 18 km and near the inner edge of the vortex did not give any evidence of upward vertical motions. However, these data, in conjunction with the other data, suggest that upward vertical motions do not play an important role in the ozone depletion process. All theories, especially the solar theory, that require elevated concentrations of oxides of nitrogen are incorrect, and the apparent absence of large-scale upward motions suggests that the K. Tong type of theory is wrong as well. Since , there has been an increase in the persistence of polar stratospheric clouds PSCs at 16, 18, and 20 km, with the PSCs persisting through October. This is possibly consistent with the temperature getting colder through October. This implies that the temperature change is a result of ozone depletion rather than a cause of it. Since it is colder in October than formerly, PSCs seem to be persisting longer now. What would be the first signs of damage to the biota in Antarctica from increased UV radiation? Presumably, the first sign would be a die-off of the phytoplankton and then the krill in the surrounding waters. Un- fortunately, there are no long-term records of the phytoplankton population over the last 20 to 40 years, so a good comparison cannot be made. Laboratory studies suggest that enhanced leveb of UV would be quite catastrophic to the phytoplankton and krill life in the region, but such measurements may not properly represent how the natural system works. How effective will the Montreal Protocol be in reduc- ing the severity of the antarctic ozone hole? There was no antarctic ozone hole from to with chlorine at a concentration of 2 ppbv. There is a huge antarctic ozone hole today with chlorine at 3 ppbv, and there is evidence that the ozone hole is enlarging and spreading. Under the Montreal Protocol, the concentration of chlorine will certainly rise to at least 5 ppbv and possibly to as high as 8 or 9 ppbv. The ozone hole may get worse, and there will be more hemispheric, and possibly global, ramifications. If policymakers believe that we should protect ozone over Antarctica, then it is quite clear that the Montreal Protsco! How is the edge of the southern polar vortex defined? This definition is not consistent with our measurements. A related question is: How fast does air move across the polar vortex boundary?

Chapter 8 : What is the difference between ozone depletion and global warming? | Socratic

ozone depletion and climate change. Starting with a description of the past and future development of the source gases that drive stratospheric change, followed by a discussion of the relevant.

There are, however, several recently described interactions between ozone depletion and greenhouse gas-induced warming. Scientists years ago would have been incredulous at the idea that, by the late twentieth century, humankind would be affecting the stratosphere. Yet, remarkably, human-induced depletion of stratospheric ozone has recently begun â€" after 8, generations of Homo sapiens. Stratospheric ozone absorbs much of the incoming solar ultraviolet radiation UVR , especially the biologically more damaging, shorter-wavelength, UVR. We now know that various industrial halogenated chemicals such as the chlorofluorocarbons CFCs â€" used in refrigeration, insulation and spray-can propellants and methyl bromide, while inert at ambient Earth-surface temperatures, react with ozone in the extremely cold polar stratosphere. This destruction of ozone occurs especially in late winter and early spring. Estimating the resultant changes in actual ground-level ultraviolet radiation remains technically complex. In the mids, governments recognised the emerging hazard from ozone depletion. The Montreal Protocol of was adopted, widely ratified, and the phasing out of major ozone-destroying gases began. The protocol was tightened in the s. Scientists anticipate a slow but near-complete recovery of stratospheric ozone by the middle of the twenty-first century. Main types of health impacts The range of certain or possible health impacts of stratospheric ozone depletion are listed in Table 8. Many epidemiological studies have implicated solar radiation as a cause of skin cancer melanoma and other types in fair-skinned humans 2. Recent assessments by the United Nations Environment Program project increases in skin cancer incidence and sunburn severity due to stratospheric ozone depletion 1 for at least the first half of the twenty-first century and subject to changes in individual behaviours. The groups most vulnerable to skin cancer are white Caucasians, especially those of Celtic descent living in areas of high ambient UVR. Further, culturally-based behavioural changes have led to much higher UV exposure, through sun-bathing and skin-tanning. The marked increase in skin cancers in western populations over recent decades reflects, predominantly, the combination of background, post-migration, geographical vulnerability and modern behaviours. Scientists expect the combined effect of recent stratospheric ozone depletion and its continuation over the next decades to be via the cumulation of additional UVB exposure , an increase in skin cancer incidence in fair-skinned populations living at mid to high latitudes 3. Laboratory studies demonstrate that exposure to UVR, in particular to UVB, in various mammalian species induces lens opacification. The epidemiological evidence for a role of UVR in human lens opacities is mixed. Cataracts are more common in some but not all countries with high UVR levels. In humans and experimental animals, UVR exposure, including within the ambient environmental range, causes both localised and whole-body immunosuppression 4. UVR-induced immunosuppression could influence patterns of infectious disease. It may also influence the occurrence and progression of various autoimmune diseases and less certainly, vaccin efficacy 5. Finally, there is a wider, ecological, dimension to consider. Ultraviolet radiation impairs the molecular chemistry of photosynthesis both on land terrestrial plants and at sea phytoplankton. This could affect world food production, at least marginally, and thus contribute to nutritional and health problems in food-insecure populations. However, as yet there is little information about this less direct impact pathway. Any public health messages concerned with personal UVR exposure should consider the benefits as well as the adverse effects. Nevertheless, we must be alert to the potential increase in some particular risks to health posed by stratospheric ozone depletion. References Environmental effects of ozone depletion: Ozone layer-climate change interactions. Influence on UV levels and UV related effects. Solar and Ultraviolet Radiation. Madronich S, de Gruijl FR. Skin cancer and UV radiation. Ultraviolet radiation and autoimmune disease: Temorshuizen F, et al. Influence of season on antibody response to high dose recombinant Hepatitis B vaccine: Estimates of ozone depletion and skin cancer incidence to examine the Vienna Convention achievements.

Chapter 9 : Is There a Connection Between the Ozone Hole and Global Warming? | Union of Concerned S

It appears unlikely that the decrease in ozone-depleting substances alone will lead to the recovery of the stratospheric ozone layer to its pre concentration levels because of the competing and uncertain effects of further climate change.

Environmental issues are not all the same. Ozone, which is made of three oxygen atoms stuck together instead of two, which is what normal oxygen gas is made of , is vital to life on Earth. It forms a layer in the stratosphere, the second layer up in the atmosphere, that is very good at absorbing ultraviolet UV radiation from the Sun. UV radiation severely damages organisms if enough of it reaches the surface. In the middle of the 20th century, synthetic gases known as chlorofluorocarbons CFCs became popular for use in refrigerators and aerosol products, among other applications. They were non-toxic, and did not react easily with other substances, so they were used widely. However, their chemical stability allowed them to last long enough to drift into the stratosphere after they were emitted. Free chlorine atoms Cl were liberated, a substance that is very reactive indeed. Over the poles, the stratosphere is cold enough for polar stratospheric clouds PSCs to form. These PSCs provided optimum conditions for the most reactive chlorine gas of all to form: It turns out that Antarctica was more favourable for ozone depletion than the Arctic, both because its temperatures were lower and because its system of wind currents prevented the ozone-depleting substances from drifting out of the area. Before long, there was a hole in the ozone layer over Antarctica due to the PSCs , and concentrations were declining in other locations too due to the basic Cl reactions. The issue became a frontier for scientific research, and scientists Crutzen, Rowland, and Molina won the Nobel Prize in Chemistry for their work with atmospheric ozone. This movement was largely successful, and the use of CFCs has become nearly negligible, especially in developed nations. The regulations are working: In contrast, climate change is a product of greenhouse gases such as carbon dioxide. Unlike CFCs, most of them are not synthetic, and they are released from the burning of fossil fuels coal, oil, and natural gas , not specific products such as refrigerators. Rather than destroying a natural process, like CFCs do, they strengthen one to the point of harm: This phenomenon, which traps heat in the atmosphere, is absolutely vital, as the Earth would be too cold to support life without it. Increasing the concentrations of greenhouse gases with fossil fuels becomes too much of a good thing, though, as the greenhouse effect traps more heat, warming the planet up. Just a few degrees Celsius of warming can cause major problems, as agricultural zones, wind and ocean currents, and precipitation patterns shift. The sea level rises, submerging coastal cities. Many species go extinct, as the climate changes faster than they can adapt. Unlike the Montreal Protocol, efforts to reduce greenhouse gas emissions have more or less failed. Fossil fuels permeate every part of our lives, and until we shift the economy to run on clean energy instead, convincing governments to commit to reductions will be difficult at best. It remains to be seen whether or not we can successfully address this problem, like we did with ozone depletion. Although these two issues are separate, they have some interesting connections. For example, PSCs form in cold areas of the stratosphere. Unfortunately, global warming is, paradoxically, cooling the stratosphere, as a stronger greenhouse effect means that less heat reaches the stratosphere. Therefore, as climate change progresses, it will make it easier for the ozone depletion reactions to occur, even though there are fewer CFCs. Additionally, CFCs are very strong greenhouse gases, but their use has drastically reduced so their radiative effects are of lesser concern to us. However, some of their replacements, HFCs, are greenhouse gases of similar strength. Finally, these two issues are similar in that ozone depletion provides a smaller-scale analogue for the kinds of political and economic changes we will have to make to address climate change: Unintended chemical side effects of our economy posed a serious threat to all species, including our own. Industry representatives and free-market fundamentalists fought tooth and nail against conclusive scientific findings, and the public became bewildered in a sea of misinformation. Governments worked together to find sensible alternatives and more or less solved the problem. Will we see the third as well?