Collection: Masterman, Vicki: Files
Folder Title: "An Assessment of the Risks of Stratospheric Modification October 1986" (3 of 3)
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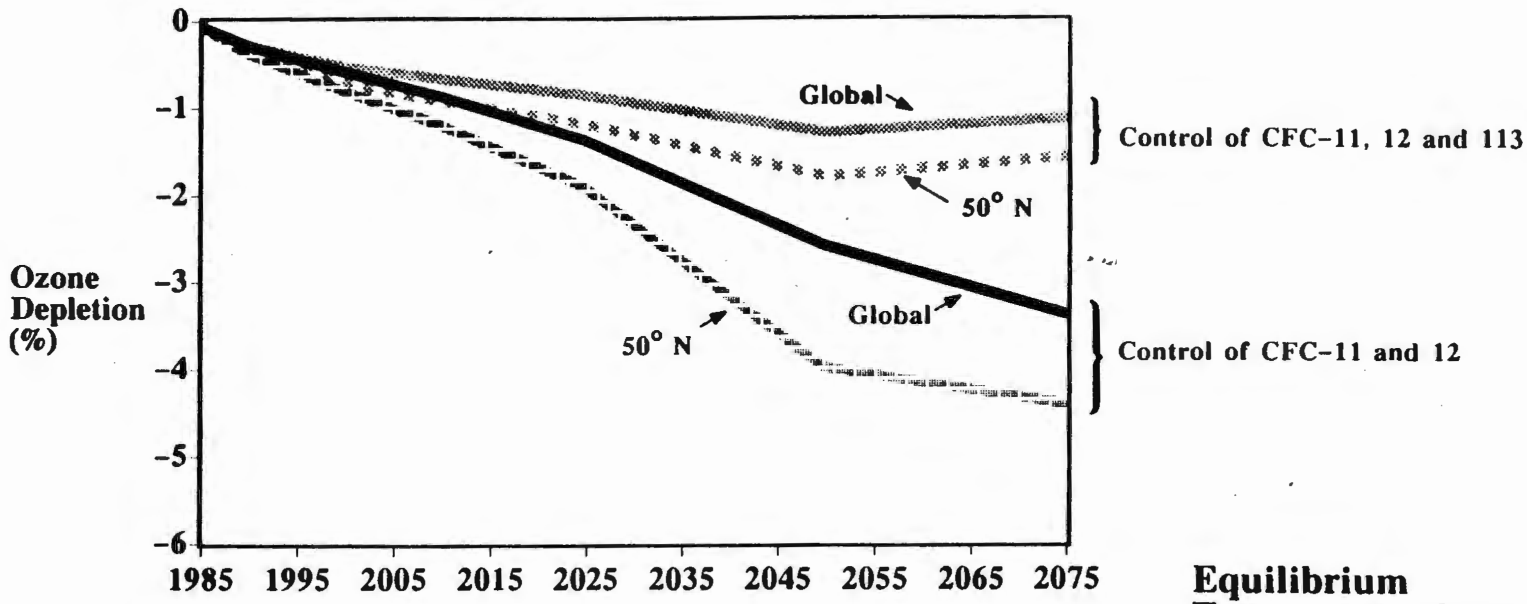
COVERAGE: WHAT SHOULD BE INCLUDED NOW?

CFC 11 & 12 Only	*CFC 11,12, & 113 Only*	*All Fully–Halogenated Substances*	*All Potential Ozone Depleters With Large Emissions*
		CFC 11	**CFC 11**
		CFC 12	**CFC 12**
		CFC 113	**CFC 113**
		Halon 1211	**CFC 22**
		Halon 1301	**Halon 1211**
			Halon 1301
			Methyl Chloroform

CONTROL OF CFC–11 AND 12 VERSUS CONTROL OF CFC–11, 12 AND 113 AT 1974 PRODUCTION LEVELS
(Assuming Developing Nations Participate)



Equilibrium Temperature Increase:
(3.0° C climate sensitivity (2075))

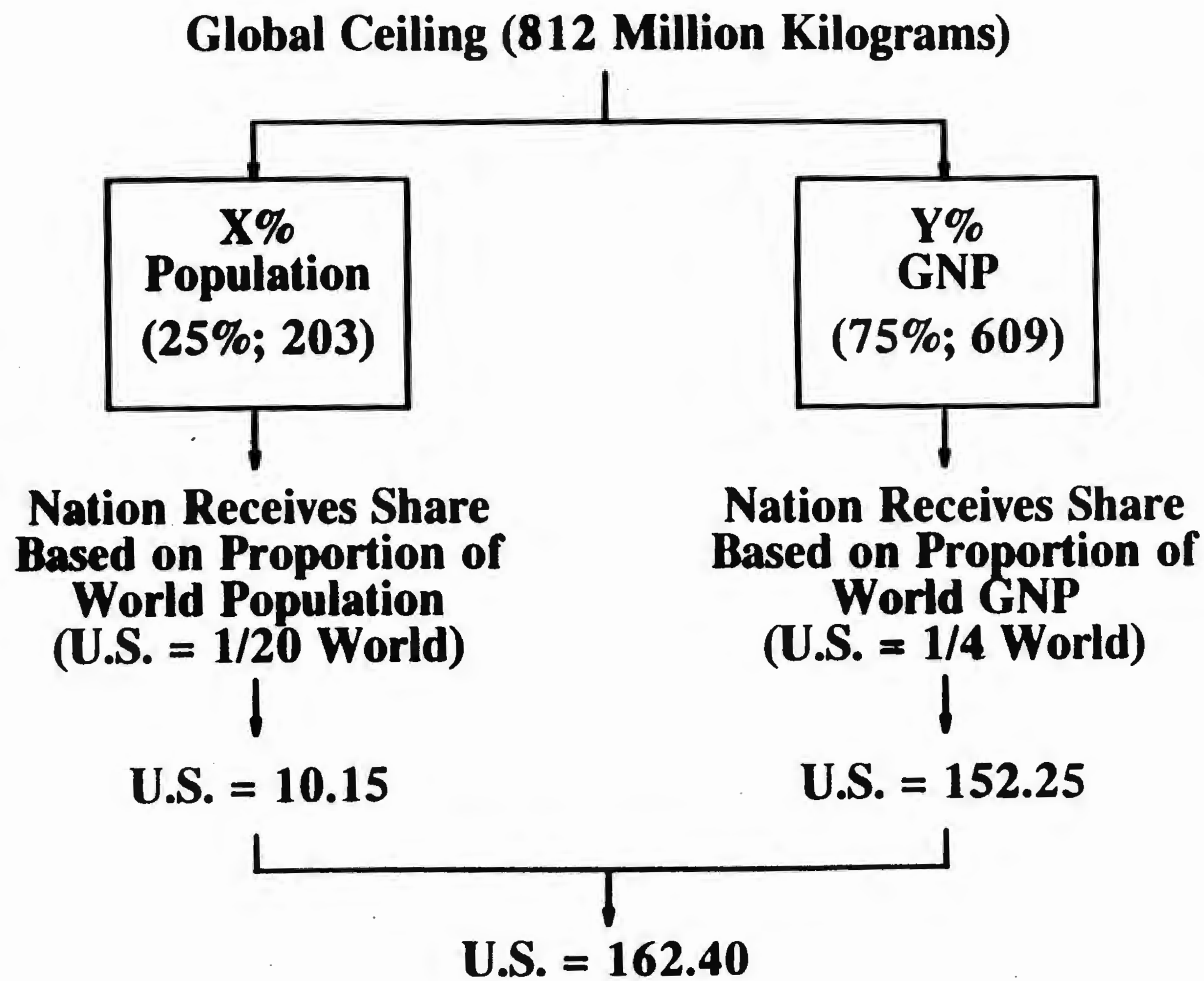
CFC–11 and 12	5.1 °C
CFC–11, 12 and 113	5.0 °C

** DO NOT CITE OR QUOTE**

ALLOCATION METHODS

- Canadian approach
- Current [production or capacity]
- Current status with no limit on developing nations until they catch up

CANADIAN PROPOSAL AND THEIR EXAMPLE



ALLOCATIONS MADE UNDER CANADIAN EXAMPLE
(Millions of Kilograms)

	Canadian Example[a]	*Current*[b] *(CFC–11 & 12)*	*Current*[b] *(CFC–11, 12, 113)*
U.S.	162.4	238.1	290.8[c]
EC	138.4	218.8[d]	259.5[e]
Japan	57.2	57.5[f]	?
East Bloc	117.3	60.0[g]	?
Canada	17.9	21.0	?
China and Centrally–Planned Asia	79.1	18.0[h]	?

a. Quotas computed using Canadian algorithm on population and GNP data for 1975 with a global emissions limit of 812 million kilograms.

b. Data for 1984 unless noted otherwise.

c. CFC–113 projected for 1983.

d. Has subtracted out exports which are 33% of total current production.

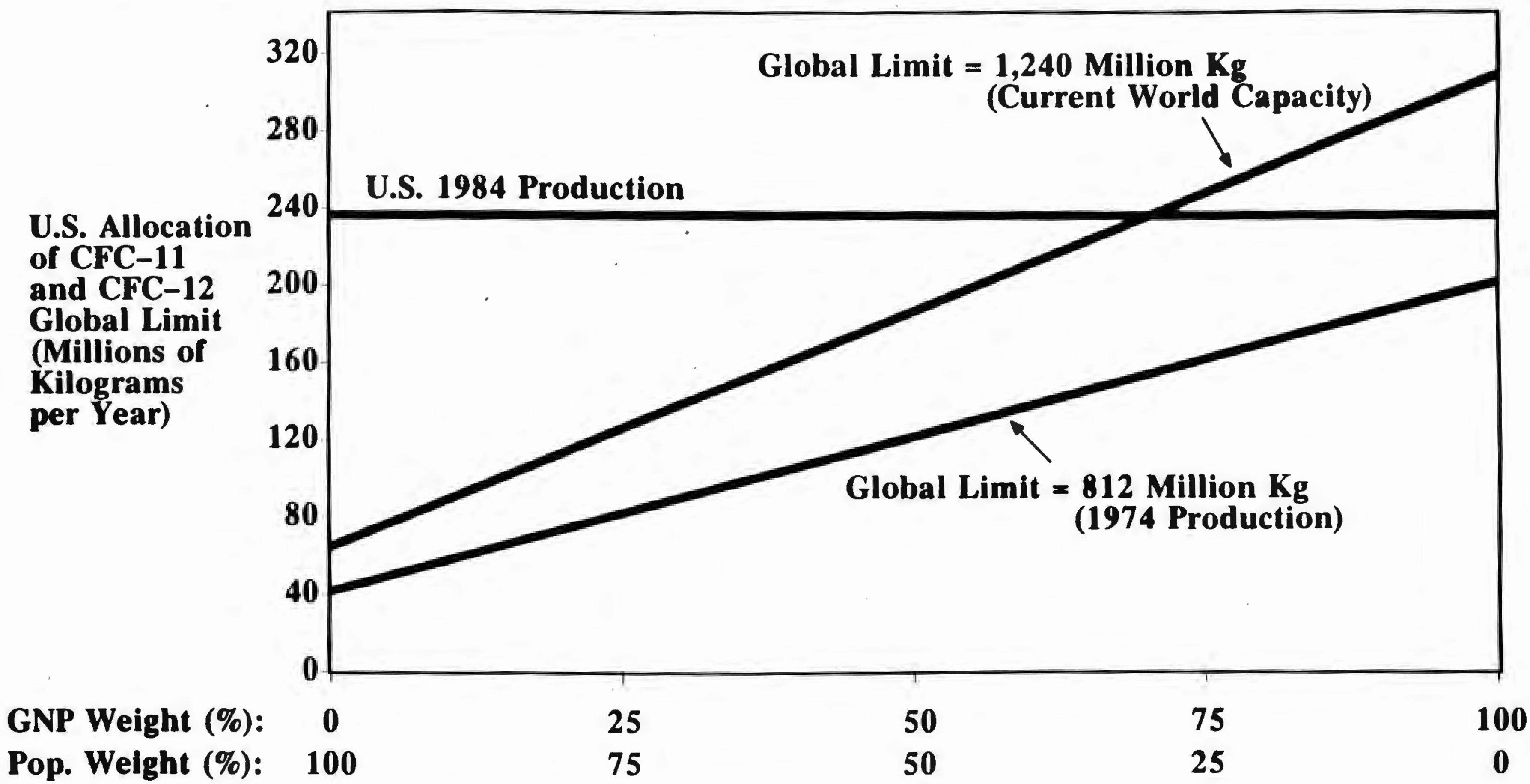
e. Also includes CFC–114.

f. Data for 1985.

g. USSR production capacity -- does not include imports.

h. China only -- does not include imports.

POTENTIAL U.S. ALLOCATION USING CANADIAN APPROACH: ALTERNATIVE WEIGHTS FOR GNP AND POPULATION



CURRENT SITUATION

- **Current production**
- **Current production capacity**

Developing and developed non–producing nations may not agree

TIMING OF OPTION REQUIREMENTS

- **Phasing**
  - **one phase**
  - **two phase**
- **When**
  - **immediately**
  - **three years**
  - **6–10 years**

Ultimate System	*1st Phase*	*2nd Phase*	*Periodic Reevaluation*
CANADIAN APPROACH	**Freeze on Production** **Freeze on New Capacity** **Freeze on Consumption**	**Full Plan**	
PRODUCTION CAPACITY	**Freeze Production Capacity**	**Full Plan**	
PRODUCTION	**Freeze on Production**	**Full Plan**	
?	**One of the above**	**Unknown**	

ASSESSING HOW OPTIONS WOULD OPERATE

EVALUATING PROPOSALS

- Flexibility
- Trade
- Incentives against free riding
- Innovation

FLEXIBILITY

	Canadian Proposal	*Production Capacity Cap*	*Production Cap*
NEW CHEMICALS	**Weights chemicals by potential ozone depletion**	**Not easy to include new chemicals**	**Production can be weighted by chemical**
CHANGE IN SCIENCE	**Readjusts global ceiling/weights**	**Requires setting production or consumption limits**	**Can be changed**

TRADE: PROHIBITIONS AND INCENTIVES

	Canadian Proposal	*Production Capacity Cap*	*Production Cap*
RESTRICTIONS ON FINISHED GOODS	**None**	**None**	**None**
IMPORTS OF BULK CHEMICALS	**Against Free Riders**	**None**	**None**
EXPORTS OF BULK CHEMICALS	**None to Free Riders**	**No Legal Barrier** **Domestic pressures to stop exporting if cap reached**	**No Legal Barrier** **Domestic pressures to stop exporting if cap reached**
CAPITAL MOVEMENT	**Free Flow**	**Free Flow Prohibited**	**Free Flow Prohibited**

INCENTIVES FOR PARTICIPATION

INCENTIVES TO	*Canadian Approach*	*Production Capacity*	*Production*
JOIN	Equal for: Importers Exporters Non-Producers	Unequal for: Countries without capacity or closer to limits	Unequal for: Non-Producers who will not want to pay higher prices/rely on others
REMAIN A MEMBER	No differential incentive to non-producers	Countries facing higher prices will leave	Countries facing higher prices will leave
IMPORT FROM FREE RIDERS	*Prohibited	**Not prohibited	**Not prohibited

*Under current version.

**If these options include import prohibitions they begin to be like Canadian Approach.

INCENTIVES FOR INNOVATION
(Options of Equal Stringency)

	Canadian Proposal	*Production Capacity Cap*	*Production Cap*
NEW CHEMICALS	**Easiest** **Chemicals are Weighted**	**Hardest** **Focus on Existing Plants**	**Same as Canadian** **If Weighting is Used**
USE OF CHEMICALS	**High**	**High, Except in Importing Countries**	**High, Except in Importing Countries**

CHLOROFLUOROCARBON/OZONE/GREENHOUSE ISSUES

"TALKING POINTS"

Background

- Chlorofluorocarbons (CFCs) have been linked theoretically since 1974 with depletion of stratospheric ozone, a gas that protects the earth from harmful effects of the sun's ultraviolet rays. More recently, CFCs also have been linked to projected long-term increases in the greenhouse effect, a natural process in which atmospheric gases keep the earth warm by trapping outgoing infrared radiation. Over the last decade, research on the atmosphere has substantially advanced our knowledge of the effects of CFCs and other trace gases on ozone and climate. As a result, scientists are now much more aware of the complexity of the chemistry and physics involved. However, the science of both issues continues to contain many uncertainties, and the computer models used to calculate potential long-term effects on the atmosphere are not yet capable of providing clear guidance to policymakers and businesses on safe, allowable growth rates or needed limits for CFC emissions. Although several aspects of these issues have been fairly well defined, we now realize that further research, perhaps over a period of several decades, will be needed to achieve an adequate understanding of the potential long-term effects of the many gases man adds to the atmosphere.

- Du Pont has spent more than $10 million on its own atmospheric modeling program and in funding academic and government research through the Chemical Manufacturers Association's Fluorocarbon Program Panel. Results have included verification of some of the key elements of the original ozone theory as well as model calculations demonstrating the importance of considering all gases with potential impacts on ozone. Industry-sponsored research has led to more than 260 peer-reviewed publications, 10 percent of them from Du Pont's in-house research.

Du Pont Position Summary

- Despite significant progress in scientific investigation of the ozone depletion and greenhouse issues, major uncertainties remain. It now seems likely many more years will pass before adequate understanding is achieved of potential long-term effects. The science continues to indicate no imminent hazard to health or the environment from CFCs at current emissions levels. However, the use of CFCs worldwide is growing, and the science is not yet sufficiently developed to define with certainty a safe CFC emissions growth rate. We conclude, therefore, that it now would be prudent to take further precautionary measures to limit worldwide emissions of CFCs while science continues to work to provide better guidance to policymakers.

- The Du Pont Company recommends that negotiations be undertaken to limit worldwide emissions of chlorofluorocarbons. Because these environmental issues are global in nature and there are significant trade and economic equity questions associated with control measures, only cooperative action among countries will be effective. Therefore, we urge the development and adoption of a protocol under the United Nations Vienna Convention for the Protection of the Ozone Layer to limit CFC emissions worldwide.

- We recommend that the U.S. EPA employ the regulatory negotiation process and appoint an advisory committee of CFC users, producers, environmental groups, and appropriate government agencies to develop a consensus on the future of CFCs. This consensus could be used to guide the U.S. Department of State in international negotiations and serve as the basis for any further U.S. regulation consistent with international agreements.

- We suggest that a needed first step in the evolution of a worldwide regulatory policy is to set worldwide emissions limits for total CFCs and to develop methods for allocating CFC emissions by regions of the world and by product type (taking into account that different CFCs have different potential for modification of the ozone layer and for adding to the greenhouse effect).

- We believe it is important for CFC producers and users to develop improved conservation and recovery practices to reduce emissions of CFCs. Du Pont is studying a variety of technical and administrative approaches to reduce emissions, and we will work with our customers to achieve this goal so that potential future hazards to the environment can be reduced while allowing essential uses of CFCs to be maintained.

- Because CFCs have so many essential uses around the world, Du Pont began a research program in the mid-1970s to identify and develop safe, environmentally acceptable, and commercially viable alternatives to the specific types of CFCs involved in the ozone issue (CFC-11, 12, 113). Our findings, published in 1980, concluded that there were a number of alternative compounds which both met the environmental safety criteria and possessed the physical properties required for application in some (but not all) of the existing market uses of the CFCs of concern. One of these alternates, F-22, is already produced in large quantities and could be employed more broadly in refrigeration and air-conditioning in place of CFC-12 if appropriate use equipment were developed.

  Neither the marketplace nor regulatory policy, however, has provided the needed incentives to make these equipment changes or to support commercialization of the other potential substitutes. If the necessary incentives were provided, we believe that alternates could be made available in volume in a time frame of roughly five years. This lead time would be needed to complete TOSCA-required toxicity testing, to design and build production facilities, and to make the necessary changes in applications equipment. We have recently reviewed and updated our earlier work and will share our assessment of the technically viable substitutes with EPA and our customers in the coming months.

<u>Product Uses Statements</u>

- Freon® fluorocarbons, comprising less than two percent of Du Pont sales, have been sold by Du Pont since the 1930's, when they were invented as a safe replacement for ammonia in refrigeration systems.

- Freon® is very low in toxicity, is non-flammable and non-explosive -- characteristics that led to its adoption in a wide variety of other uses, such as blowing agents for plastic foams used in insulation, cushioning and packaging; cleaning agents for electronic components; and air conditioning, today believed by many to be the essential technology allowing growth of major metropolitan centers in warmer climates.

- The products are essential to food and medical distribution and storage systems throughout much of the world. Lesser developed countries project increased health and economic progress through growing use of refrigeration employing CFCs.

- CFC products such as Freon® are manufactured by 31 companies worldwide operating in all of the world's developed regions. In the U.S. alone, CFCs are used by some 5,000 businesses at nearly 375,000 locations to produce goods and services worth more than $28 billion a year. U.S. CFC-related jobs are tallied at 780,000.

- Not all CFCs have the same potential for modification of the ozone layer and adding to the greenhouse effect. Those that contain hydrogen, F-22 for example, are much less stable in the atmosphere and, therefore, have significantly less potential effect than the fully halogenated CFCs, such as CFC-11 or CFC-12. F-22, which already finds limited use as a refrigerant, has been noted by regulators and scientists as a potential broad substitute for CFC-12 in refrigeration and air-conditioning applications.

THE CFC/OZONE ISSUE

What is the Ozone Layer?

The atmosphere above the earth is composed of several layers. The bottom layer, the troposphere, extends from the surface to an altitude of about eight miles. The stratosphere extends from the top of the troposphere to about 30 miles.

Ozone (O_3) is formed naturally from molecular oxygen (O_2) primarily through the action of high energy light from the sun. Ozone is present in the atmosphere in low concentrations distributed over a wide altitude range, but about 90 percent of the total amount of ozone is located in the stratosphere. This stratospheric ozone is commonly referred to as the ozone layer.

What Function Does Ozone Serve?

Ozone acts as a filter to limit the amount of high-energy solar ultraviolet radiation (UV-B radiation) reaching the surface of the earth. Decreases in the amount of ozone in the atmosphere, therefore, would permit an increase in the amount of UV-B reaching the earth's surface. Increases in UV-B could lead to harmful effects to plant and animal life. For example, exposure to UV-B radiation contributes to the formation of some types of human skin cancer.

What Determines the Amount of Ozone in the Atmosphere?

The amount of ozone in the atmosphere is controlled by dynamic balances between production (primarily by the action of high-energy solar radiation on O_2) and destruction (by a variety of chemical cycles), and by mixing in the atmosphere. Reliable understanding of atmospheric ozone and its cycles has been slow, however, due to: 1) the complicated interaction between solar radiation, chemistry, and atmospheric motions, such as air flow; 2) the rapid, natural formation and destruction of atmospheric ozone (up to 300 million tons of ozone are produced and destroyed in the atmosphere each day); 3) the low concentrations of the chemicals involved (parts per million to parts per trillion); and 4) the large number of chemicals and reactions that must be considered (there are more than 40 chemicals and about 150 chemical reactions included in current computer simulations).

What is the Ozone Depletion Theory?

In 1974, two U.S. scientists proposed a theory that chlorofluorocarbons (CFCs) released into the troposphere could cause a reduction of ozone in the stratosphere. The theory involves several steps. First, CFCs released at the surface of the earth are not destroyed in the troposphere but slowly mix into the stratosphere. Once in the stratosphere, the CFCs are decomposed by high-energy radiation from the sun to release chlorine. Then, through a series of reactions, chlorine would destroy ozone without destroying itself. The final step is for the chlorine to mix down into the troposphere where it is rapidly and harmlessly removed. The potential effect of this process would be a reduction in the balance of ozone in the atmosphere.

In 1974, there was very little scientific data to prove or disprove the theory. For example, none of the important chlorine compounds had been measured in the stratosphere.

Is the Theory Correct?

Research carried out since 1974 has shown portions of the original theory to be correct, but it has also shown that the processes controlling ozone in the stratosphere are much more complicated than originally believed and that there are compensating factors that can increase ozone. Research has provided evidence that: 1) very little, if any, of the CFCs are destroyed in the troposphere*, 2) CFCs do mix into the stratosphere, 3) once there, they are decomposed to release chlorine, and 4) the chlorine is removed from the stratosphere through atmospheric mixing. It is the intermediate steps involving the reactions of chlorine compounds that are very complicated and can produce offsetting effects. Also, a full description of possible changes in the total amount of ozone requires consideration of the effects of other compounds whose concentrations are changing as a result of human activities.

What Method is Used to Predict Future Ozone Levels?

Complex computer models are used to attempt simulations of atmospheric ozone. The models rely on laboratory measurements of the rates of the chemical reactions as input. The models are "tested" by comparing model calculated results for the

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* Those CFCs containing hydrogen, e.g., F-22, are an exception, since they are rapidly and harmlessly destroyed in the troposphere.

concentrations of the various atmospheric chemicals with actual atmospheric measurements. The models can also be used to forecast possible future states of the atmosphere - including future amounts of ozone.

How Good are the Computer Models?

Although there is general agreement between model calculated and measured concentrations of most of the compounds, there are important differences. For example, model calculations of the current upper atmosphere yield ozone values that are 30 percent to 50 percent different than values obtained by actual measurements. But we cannot expect the models to be perfect because the physical constants needed as model input all contain uncertainties which combine and propagate through the model calculations to produce uncertainties in the results. In addition, scientists may be overlooking important atmospheric processes and, if so, those processes are not taken into account in the models. Finally, the atmosphere is three dimensional with variations in ozone, chemistry, and atmospheric motions at different altitudes, latitudes and longitudes. But, most of the current models of the atmosphere consider only one dimension - altitude - or two dimensions - altitude and latitude. This requires that the complex three-dimensional motions of the atmosphere be averaged to the one or two dimensions of the models. At this time, scientists have neither the knowledge nor the computer resources to represent the true three-dimensional character of the atmosphere.

There is an additional complication to using models to forecast ozone amounts. For each of the compounds that control the total amount of ozone, there are one or more precursor gases. Measurements have shown that the atmospheric concentrations of several of these precursors are increasing - in some cases, for unknown reasons. These gases include methane and nitrous oxide. The concentration of carbon dioxide, which influences ozone via its direct affect on stratospheric temperatures, also is increasing. Model results indicate that increasing concentrations of methane and carbon dioxide may increase ozone while increasing concentrations of nitrous oxide and CFCs may decrease ozone. Therefore, accurate forecasting of ozone levels requires accurate values for the future concentrations of all these gases. Since this information is not available, however, estimates must be used, and considerable uncertainty is introduced into the forecast results.

What Do Ozone Measurements Show?

Analyses of the longest running continuous set of actual ozone measurements show that there has been <u>no</u> persistent change in the total amount of ozone. This result has been reported in recent science assessment reports. This result is based on analyses of data from a globally distributed set of 36 ground-based ozone monitoring stations that have been operating for 25 to 30 years.

The measurements also show that ozone concentrations naturally fluctuate on time scales ranging from hours to 11 years. For example, ozone fluctuates by 10 percent to 30 percent from day to day over the United States; month-to-month fluctuations are about 25 percent with a strong seasonal cycle. Also, average total ozone over areas of the northern U.S. is about 15 percent greater than total ozone over areas of the southern U.S.

There have been recent reports of an unpublished analysis of ozone measurements by a satellite-based instrument showing a roughly 2.5-percent decrease in the global amount of ozone over the last six to seven years. Over that time, however, the accuracy of the instrument has slowly diminished. Because the degradation gives a large artificial signal that "looks like" ozone depletion, it is difficult to separate it from any small real ozone decrease. Consequently, scientists see a need to reanalyze the data to insure that the known degradation of the instrument is accounted for properly. The data also must be more carefully compared to the better understood ground-based measurements to determine the reliability of the satellite data.

If the satellite-based instrument's observed ozone decreases prove to be real, scientists must then compare these changes to the long-term fluctuations observed by the ground-based instruments. There are several possible causes for such changes, including: natural changes in the amount of high-energy light received from the sun (which would cause natural changes in the production of ozone as well as changes in concentrations of chemicals that decompose ozone) or fluctuations in the total amount of ozone due to such natural causes as volcanic eruptions.

What is the Antarctic Ozone Phenomenon and What Does It Mean?

Scientists have recently recognized that the total amount of ozone over the Antarctic continent has decreased significantly during successive Octobers since the mid-1970s. The decrease cannot be explained based on current knowledge of atmospheric processes. Three types of hypotheses have been proposed to explain the observations: one involves chlorine compounds resulting from CFC emissions; another relates the phenomenon to natural fluctuations resulting from variations in the amount of high-energy light with the solar cycle; and a third explains the decreases by postulating changes in air motions in the stratosphere. Each of the hypotheses has its strengths and weaknesses but none has been established as most probable by scientists. More information is needed to distinguish among them or to show that they are all wrong and another hypothesis is needed.

This is a very active field of research. Scientists are analyzing all available data to better understand this unique region of the atmosphere. Extensive measurement campaigns to the Antarctic are planned for August to November of both 1986 and 1987. Laboratory studies to investigate newly proposed chemical mechanisms are underway. Progress toward a better understanding of this phenomenon is expected to be slow, despite all the efforts. Until scientists have a better understanding of the phenomenon, it is impossible to determine the implications of this event to the global atmosphere. However, it should be pointed out that so far the phenomenon is localized and the area in which it is occurring is unique from the standpoint of both chemistry and air motions. For these reasons, it appears that the phenomenon could remain a localized event.

What Can We Conclude?

Even though there remain uncertainties associated with model forecasts of future ozone levels, we do have some strong indications of what might happen to the total amount of ozone as a result of man's activities. These indications are based on a combination of model forecasts and actual atmospheric measurements of ozone and other key compounds. The information available indicates that there will be only minor changes in the globally averaged total amount of ozone (either an increase or a decrease) as a result of all human activities if CFC releases do not increase significantly. However, sustained growth in the rate of CFC releases could, according to the models, cause a depletion of the total amount of ozone during the next century.

Scientific research will continue to reduce uncertainties and provide better tools for forecasting ozone amounts. Due to the complexities of atmospheric ozone, however, it is likely that many more years of research will be required to provide accurate 100-year forecasts.

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