Collection: Masterman, Vicki: Files
Folder Title: Stratospheric Ozone IV (3 of 8)
Box: 2

51. DETERMINATION OF UV-B EXPOSURE IN AQUATIC SYSTEMS IS COMPLEX BECAUSE OF THE VARIABLE ATTENUATION OF UV-B RADIATION IN THE WATER COLUMN.

51a. Because aquatic organisms are small and do not usually have fixed locations, it is very difficult to obtain accurate data needed to model the systems and verify results. Current understanding of the life cycle of organisms is very limited. (See page ___.)

52. ABOUT ONE HALF OF THE WORLD'S PROTEIN IS DERIVED FROM MARINE SPECIES. IN MANY THIRD WORLD COUNTRIES, THIS PERCENTAGE IS LARGER. RESEARCH IS NEEDED TO IMPROVE OUR UNDERSTANDING OF HOW OZONE DEPLETION COULD INFLUENCE THESE SYSTEMS.

52a. A comprehensive analysis of sublethal and lethal effects of solar UV on littoral, benthos, and planktonic ecosystems is needed.

52b. A model of energy flow analysis leading to protein production where solar input is augmented by increased ultraviolet radiation would be required to better evaluate potential effects. Marine organisms responses to projected increases in UV must be considered in the context of the oceans as a dynamic moving fluid.

52c. Better documentation of the effects of present levels of ultraviolet light on marine organisms is needed.

52d. Intensive research is needed to identify biochemical indices that reflect UV stress in marine organisms.

53. INCREASED UV-B RADIATION WILL ACCELERATE THE DEGRADATION OF POLYMERS.

53a. Several commercial polymers (e.g., polyethylene, polypropylene, poly(vinylchloride)), although theoretically UV transparent, contain chromophore impurities that absorb light in the UV-B region of the spectrum. Other polymers (e.g., polycarbonate) have structural features in their molecules that result in strong UV-B light absorption. (See page ___.)

53b. Several polymers have important outdoor applications (e.g., used in siding and window glazing in the building industry, in film and containers in packaging, in housewares and toys, and in paints and protective coatings). Such polymers are likely to be exposed to significant amounts of UV-B radiation. Other polymers are stored outside before use and could deteriorate during these periods. (See page ___.)

53c. Absorption of UV-B radiation in polymers causes photo-induced reactions and alters important mechanical, physical, or optical properties of the polymers (e.g., yellowing, brittleness) and thus degrades (i.e., reduces the useful life of) the polymers. (See page ______.)

54. INCREASED USE OF UV-STABILIZERS FOR PROTECTION OF POLYMERS AGAINST UV RADIATION WOULD HAVE NEGATIVE EFFECTS.

54a. Increased amounts of stabilizers might adversely affect the processing and use properties of some polymers (e.g., hardness, thermal conductivity, flow characteristics). For example, increased amounts of titanium dioxide in poly(vinylchloride) might affect its processing properties, increasing its costs of production. (See page ___.)

54b. Changes in the amount of stabilizer (and other additives) would increase costs of products. Alternatively, manufacturers could develop new formulations to avoid or minimize impurities in production. (See page ___.)

54c. The addition of stabilizers to polymers may be limited by practical problems of material characteristics or manufacture. However, other responses may be possible to limit damage. (See page ___.)

55. INCREASED UV-B RADIATION DUE TO OZONE DEPLETION COULD HAVE ADVERSE ECONOMIC EFFECTS.

55a. Changes in polymer processing properties can result in more equipment shutdowns, higher maintenance costs, and increased utility costs. (See page ___.)

55b. Increased operating costs and material costs (e.g., for stabilizers, lubricants, and other additives) would have an adverse economic impact on the polymer/plastic and related industries. (See page ___.)

55c. In a case study using preliminary data and methods, and a given scenario of ozone depletion (26% depletion by 2075), undiscounted cumulative (1984-2075) economic damage for poly(vinylchloride) is estimated at $4.7 billion (USA only). Due to the lack of data, possible damage to other polymers has not been assessed. (See page ___.)

56. POTENTIAL DAMAGES TO POLYMERS RELATED TO OZONE DEPLETION AND CLIMATE CHANGE ARE DIFFICULT TO ESTIMATE.

56a. Due to lack of relevant experimental data, only approximate estimation methods are available to determine the potential extent of light-induced damage to polymers and other materials. (See page ___.)

56b. Depending upon the chemical nature of a polymer, the components of the compound, and the weathering factors, both temperature and humidity tend to increase the rate of degradation. (See page __.)

56c. Research on dose-response relationships for polymers could increase our ability to project the effects of ozone depletion.

56d. Actual action spectra need to be developed for different polymers.

56e. The feasibility of different mitigation measures needs to be experimentally determined.

56f. The synergistic effects of increased humidity and temperature need to be considered.

57. RESULTS FROM ONE MODELING STUDY AND ONE CHAMBER STUDY SUGGEST THAT INCREASED ULTRAVIOLET RADIATION FROM OZONE DEPLETION MAY INCREASE THE RATE OF TROPOSPHERIC OZONE FORMATION.

57a. According to these studies, increases in UV-B associated with ozone depletion would increase the quantity of ground-based ozone associated with various hydrocarbon and nitrogen oxides emission levels. Results for individual cities vary, depending on the city's location and on the exact nature of the pollution. (See page ___.)

57b. According to these studies, global warming would enhance the effects of increased UV-B radiation on the formation of ground-based ozone. (See page ___.)

57c. According to these studies, ground-based ozone would form closer to urban centers. This would cause larger populations in some cities to be exposed to peak values. (See page ___.)

57d. More research is needed to verify and expand the results of these initial studies.

58. PRELIMINARY RESULTS FROM ONE STUDY ALSO SUGGEST THAT LARGE INCREASES IN HYDROGEN PEROXIDE WOULD RESULT FROM INCREASED UV-B RADIATION.

58a. If hydrogen peroxide increases as predicted in this study, the oxidizing capability potential of the atmosphere, including the formation of acid rain, would be influenced. (See page ___.)

58b. More research, especially a chamber study, is needed to verify this effect.

59. INCREASES IN GROUND-BASED OZONE WOULD ADVERSELY AFFECT PUBLIC HEALTH AND WELFARE.

59a. If UV-B increases enhanced ozone production, more U.S. cities would be unable to meet health-based ground-level ozone standards, and background ozone would increase. (See page ___.)

59b. Crops, ecosystems, and materials would be adversely affected by increased ground-level ozone. (See page ___.)

60. THE PROJECTED GLOBAL WARMING WOULD ACCELERATE THE CURRENT RATE OF SEA LEVEL RISE BY EXPANDING THE DENSITY OF OCEAN WATER, MELTING ALPINE GLACIERS, AND EVENTUALLY INCREASING THE RATE AT WHICH POLAR ICE SHEETS MELT OR DISCHARGE ICE INTO THE OCEANS.

61. GLOBAL AVERAGE SEA LEVEL APPEARS TO HAVE RISEN 10 TO 15 CM OVER THE LAST CENTURY.

61a. Studies of the possible contribution of thermal expansion and alpine meltwater to sea level rise, based on the 0.6°C warming of the past century, indicate that these two sources are insufficient to explain the estimated sea level rise that has occurred during this period. Consequently, some other source, such as melting of the polar ice caps, must be considered a possibility. (See page ___.)

62. ESTIMATES OF THE RISE IN SEA LEVEL THAT COULD TAKE PLACE IF MEASURES TO LIMIT THE GLOBAL WARMING ARE NOT UNDERTAKEN RANGE FROM 10 TO 20 CM BY THE YEAR 2025, AND 50 TO 200 CM BY 2100.

62a. According to published studies, thermal expansion of the oceans alone would increase sea level rise between about 30 cm and 100 cm by 2100, depending on the realized temperature change. This is the most certain contribution. (See page ___.)

62b. Melting of alpine glaciers and possibly of ice on Greenland could each contribute 10 to 30 cm through 2100, depending on the scenario. This contribution also has a high degree of likelihood. (See page ___.)

62c. The contribution of Antarctic deglaciation is more difficult to project. It has been estimated at between 0 and 100 cm; however, the possibilities cannot be ruled out that (1) increased snowfall could increase the size of the Antarctic ice sheet and thereby partially offset part of the sea level rise from other sources; or (2) meltwater and enhanced calving of the ice sheet could increase the contribution of Antarctic deglaciation to as much as 2 m. The Antarctic contribution to sea level rise may be more sensitive to time delays after certain threshold conditions are reached than to the magnitude of total warming. (See page ___.)

63. OVER THE MUCH LONGER TERM (THE NEXT FEW CENTURIES) DISINTEGRATION OF THE WEST ANTARCTIC ICE SHEET MIGHT RAISE SEA LEVEL BY 6 METERS.

63a. If a distintegration takes place, glaciologists generally believe that such a complete disintegration of the west Antarctic ice sheet would take at least 300 years, and probably at least 500 years. (See page ___.)

63b. A global warming might result in sufficient thinning of the Ross and Filcher-Ronne Ice Shelves in the next century to make the process of disintegration irreversible. (See page ___.)

64. <u>LOCAL TRENDS IN SUBSIDENCE AND EMERGENCE MUST BE ADDED OR SUBTRACTED TO GLOBAL RISK ESTIMATES IN ORDER TO ESTIMATE RELATIVE SEA LEVEL RISE AT PARTICULAR LOCATIONS</u>.

64a. Most of the Atlantic and Gulf Coasts of the United States--as well as the Southern Pacific coast--are subsiding 10-20 cm per century. (See page ___.)

64b. Louisiana is subsiding 1 m per century, while parts of Alaska are emerging 10-150 cm per century. (See page ___.)

64c. Due to subsidence already occurring in areas such as Bangladesh, Bangkok, and the Nile delta, these areas are extremely vulnerable to sea level rise.

65. <u>A SUBSTANTIAL RISE IN SEA LEVEL WOULD PERMANENTLY INUNDATE WETLANDS AND LOWLANDS, ACCELERATE COASTAL EROSION, EXACERBATE COASTAL FLOODING, AND INCREASE THE SALINITY OF ESTUARIES AND AQUIFERS</u>.

65a. Louisiana is the state most vulnerable to a rise in sea level. Important impacts would also occur in Florida, Maryland, Delaware, New Jersey, and in the coastal regions of other states. (See page ___.)

65b. A rise in sea level of 1 to 2 m by the year 2100 could destroy 50 percent to 80 percent of U.S. coastal wetlands. (See page ___.)

65c. Limited studies predict that increased salinity from sea level rise would convert cypress swamps to open water and threaten drinking water supplies in areas such as Louisiana, Phildelphia, and New Jersey. Other areas, such as Southern Florida, may also be vulnerable but have not been investigated. (See page ___.)

65d. Studies of Bangladesh and the Nile River Delta indicate that these river deltas, which are already subsiding, would be greatly affected by rising sea level, experiencing significant economic and environmental losses.

66. <u>EROSION PROJECTED IN VARIOUS STUDIES TO RESULT FROM ACCELERATED SEA LEVEL RISE COULD THREATEN U.S. RECREATIONAL BEACHES</u>.

66a. Case studies of beaches in New Jersey, Maryland, California, South Carolina, and Florida have concluded that a 30-cm rise in sea level would result in beaches eroding 20-60 m or more. Major beach preservation efforts would be required if recreational beaches are to be maintained. (See page ___.)

67. ACCELERATED SEA LEVEL RISE WOULD INCREASE THE DAMAGES FROM FLOODING IN COASTAL AREAS.

67a. Flood damages would increase because higher water levels would provide a higher base for storm surges. (See page ___.)

67b. Erosion would increase the vulnerability to storm waves, and decreased natural and artificial drainage would increase flooding during rainstorms. (See page ___.)

68. ESTIMATES OF DAMAGE FROM SEA LEVEL RISE MUST CONSIDER POSSIBLE MITIGATION BY HUMAN RESPONSES.

68a. The adverse impacts of sea level rise could be ameliorated through anticipatory land use planning and structural design changes. (See page ___.)

68b. In a case study of two cities, Charleston, South Carolina, and Galveston, Texas, accelerated anticipatory planning was estimated to reduce net damages by 20 to 60 percent. (See page ___.)

69. RELATED IMPACTS OF A GLOBAL WARMING WOULD ALSO AFFECT IMPACTS OF SEA LEVEL RISE.

69a. Increased droughts might amplify the salinity impacts of sea level rise. (See page ___.)

69b. Increased hurricanes and increased rainfall in coastal areas could amplify flooding from sea level rise. (See page ___.)

69c. Warmer temperatures might impair peat formation of salt marshes and would enable mangrove swamps to take over areas that are presently salt marsh. (See page ___.)

69d. Decreased northeasterners might reduce damage. (See page __.)

70. RESEARCH OPPORTUNITIES EXIST TO IMPROVE SEA LEVEL RISE ESTIMATES AND IMPACTS.

70a. The most critical areas of research for reducing the variation in estimates of future sea level rise are ice melting and runoff in Antarctica and Greenland and ice discharge.

70b. Research in glacial discharge in Antarctica should focus not just on West Antarctica, but on Pine Island and East Antarctica.

70c. An improved program of tidal gauge stations, especially in the southern hemisphere, and satellite altimetry should be used to measure sea level rise and the mass balance of ice sheets.

71. <u>CLIMATE CHANGE HAS HAD A SIGNIFICANT IMPACT ON FORESTS IN THE PAST. IF CURRENT PREDICTIONS PROVE ACCURATE, THERE IS A POTENTIAL FOR DRAMATIC SHIFTS IN FORESTS AND VEGETATION OVER THE NEXT 100 YEARS.</u>*

71a. Climate models predict that a global warming of approximately 1.5°C to 4.5°C will be induced by a doubling of atmospheric CO_2 and other trace gases during the next 50 to 100 years. The period 18,000 to 0 years B.P. is the only general analog for a global climate change of this magnitude. The geological record from this glacial to inter-glacial interval provides a basis for qualitatively understanding how vegetation may change in response to large climatic change. (See page ___.)

71b. The paleovegetational record shows that climatic change as large as that expected to occur in response to CO_2 doubling is likely to induce significant changes in the composition and patterns of the world's biomes. Changes of 2°C to 4°C have been significant enough to alter the composition of biomes, and to cause new biomes to appear and others to disappear. At 18,000 B.P., the vegetation in eastern North America was quite distinct from that of the present day. The cold, dry climate of that time seems to have precluded the widespread growth of birch, hemlock, beech, alder, hornbeam, ash, elm, and chestnut, all of which are fairly abundant in present-day deciduous forest. Southern pines were limited to grow with oak and hickory in Florida. (See page ___.)

71c. Available paleoecological and paleoclimatological records do not provide an analog for the high rate of climate change and unprecedented global warming predicted to occur over the next century. Previous changes in vegetation have been associated with climates that were nearly 5°C to 7°C cooler and took thousands of years to evolve rather than decades, the time during which such changes are now predicted to occur. Insufficient temporal resolution (e.g., via radiocarbon dates) limits our ability to analyze the decadal-scale rates of change that occurred prior to the present millennium. (See page ___.)

71d. Limited experiments conducted with dynamic vegetation models for North America suggest that decreases in net biomass may occur and that significant changes in species composition are likely. Experiments with one model suggest that eastern North American biomass may be reduced by 11 megagrams per hectare (10% of live biomass) given the equivalent of a doubled CO_2 environment. Plant taxa will respond individualistically rather than as whole communities to regional changes in climate variables. At this time such analyses must be treated as only suggestive of the kinds of change that could occur. Many critical processes are simplified or

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* Findings 73 to 76 are summarized from Appendix B, which provides a comprehensive review of potential impacts of global climate change.

omitted and the actual situation could be worse or better. (See page ___.)

71e. Future forest management decisions in major timber-growing regions are likely to be affected by changes in natural growing conditions. For example, one study suggests that loblolly pine populations are likely to move north and northeast into Pennsylvania and New Jersey, while its range shrinks in the west. The total geographic range of the species may increase, but a net loss in productivity may result because of shifts to less accessible and less productive sites. While the extent of such changes is unclear, adjustments will be needed in forest technology, resource allocation, planning, tree breeding programs, and decision-making to maintain and increase productivity. (See page ___.)

71f. Dynamic vegetation models based on theoretical descriptions of all factors that could influence plant growth must be improved and/or developed for all major kinds of vegetation. In order to make more accurate future predictions, these models must be validated using the geological record and empirical ecological response surfaces. In particular, the geological record can be used to test the ability of vegetation models to simulate vegetation that grew under climate conditions unlike any of the modern day conditions. (See page ___.)

71g. Dynamic vegetation models should incorporate direct effects of atmospheric CO2 increases on plant growth and other air pollution effects. Improved estimates of future regional climates are also required in order to make accurate predictions of future vegetation changes. (See page ___.)

72. <u>LIMITED ASSESSMENTS SUGGEST THAT IMPORTANT CHANGES IN AGRICULTURE AND FARM PRODUCTIVITY ARE LIKELY THROUGHOUT THE WORLD IF CLIMATE CHANGE OCCURS AS PREDICTED. ESTIMATES OF IMPACTS ON SPECIFIC REGIONS ARE DIFFICULT TO MAKE BECAUSE REGIONAL PROJECTIONS OF CHANGE CANNOT BE RELIABLY MADE. CURRENT CLIMATIC KNOWLEDGE IS ONLY SUFFICENT TO SUPPORT VULNERABILITY STUDIES FOR ALTERNATIVE SCENARIOS</u>.

72a. Climate has had a significant impact on farm productivity and geographical distribution of crops. Examples include the 1983 drought, which contributed to a nearly 30 percent reduction in corn yields in the U.S.; the persistent Great Plains drought between 1932-1937, which contributed to nearly 200,000 farm bankruptcies; and the climate shift of the Little Ice Age (1500-1800), which led to the abandonment of agricultural settlements in Scotland and Norway. (See page ___.)

72b. World agriculture is likely to undergo significant shifts if trace-gas-induced climate warming in the range of 1.5°C to 4.5°C occurs over the next 50 to 100 years. Climatic effects on agriculture will extend from local to regional and international levels. However, modern agriculture is very dynamic and is constantly responding to changes in production, marketing, and government programs. (See page ___.)

72c. The main effects likely to occur at the field level will be physical impacts of changes in thermal regimes, water conditions, and pest infestations. High temperatures have caused direct damage to crops such as wheat and corn; moisture stress, often associated with elevated temperatures, is harmful to corn, soybean, and wheat during flowering and grain fill; and increased pests are associated with higher, more favorable temperatures. (See page ____.)

72d. Even relatively small increases in the mean temperature can increase the probability of harmful effects in some regions. Analysis of historical data has shown that an increase of 1.7°C (3°F) in mean temperature changes by about a factor of three the likelihood of a five-consecutive-day maximum temperature event of at least 35°C (95°F) occurring in a city like Des Moines. In regions where crops are grown close to their maximum tolerance limits, extreme temperature events may have significant harmful effects on crop growth and yield. (See page ___.)

72e. Limited experiments using climate scenarios and agricultural productivity models have demonstrated the sensitivity of agricultural systems to climate change. Future farm yields are likely to be affected by climate because of changes in the length of the growing season, heating units, extreme winter temperatures, precipitation, and evaporative demand. In addition, field evaluations show that total productivity is a function of the drought tolerance of the land and the moisture reserve, the availability of land, the ability of farmers to shift to different crops, and other factors. (See page ___.)

72f. The transition costs associated with adjusting to global climatic change are not easily calculated, but are likely to be very large. Accommodating to climate change may require shifting to new lands and crops, creating support services and industries, improving and relocating irrigation systems, developing new soil management and pest control programs, and breeding and introducing new heat- or drought-tolerant species. The consequences of these decisions on the total quantity, quality, and cost of food are difficult to predict. (See page ___.)

72g. Current projections of the effects of climate change on agriculture are limited because of uncertainties in predicting local temperature and precipitation patterns using global climate models, and because of the need for improved research studies using controlled atmospheres, statistical regression models, dynamic crop models and integrated modeling approaches. (See page ___.)

73. <u>WATER RESOURCE SYSTEMS HAVE UNDERGONE IMPORTANT CHANGES AS THE EARTH'S CLIMATE HAS SHIFTED IN THE PAST. CURRENT ANALYSES SUGGEST AN INTENSIFIED HYDROLOGIC CYCLE, IF CLIMATE CHANGE OCCURS AS PREDICTED.</u>

73a. There is evidence that climate change since the last ice age (18,000 years B.P.) has significantly altered the location of lakes -- although the extent of present day lakes is broadly comparable with 18,000 years B.P. For example, there is evidence indicating the existence of many tropical lakes and swamps in the Sahara, Arabian, and Thor Deserts around 9,000 to 8,000 years B.P. (See page ___.)

73b. The inextricable linkages between the water cycle and climate ensure that potential future climate change will significantly alter hydrologic processes throughout the world. All natural hydrologic processes--precipitation, infiltration, storage and movement of soil moisture, surface and subsurface runoff, recharge of groundwater, and evapotranspiration--will be affected if climate changes. (See page ___.)

73c. As a result of changes in key hydrologic variables such as precipitation, evaporation, soil moisture, and runoff, climate change is expected to have significant effects on water availability. Early hydrologic impact studies provide evidence that relatively small changes in precipitation and evaporation patterns might result in significant, perhaps critical, changes in water availability. For many aspects of water resources, including human consumption, agricultural water supply, flooding and drought management, groundwater use and recharge, and reservoir design and operation, these hydrologic changes will have serious implications. (See page ___.)

73d. Despite significant differences among climate change scenarios, a consistent finding among hydrologic impact studies is the prediction of a reduction in summer soil moisture and changes in the timing and magnitude of runoff. Winter runoff is expected to increase and summer runoff to decrease. These results appear to be robust across a range of climate change scenarios. (See page __.)

73e. Future directions for research and analyses suggest that improved estimates of climate variables are needed from large-scale climate models; innovative techniques are needed for regional assessments; increased numbers of assessments are necessary to broaden our knowledge of effects on different users; and increased analyses of the impacts of changes in water resources on the economy and society are necessary. (See page ___.)

74. MORBIDITY AND MORTALITY RATES ARE ASSOCIATED WITH WEATHER EXTREMES IN OUR SOCIETY.

74a. Weather has a profound effect on human health and well being. It has been demonstrated that weather is associated with changes in birth rates, outbreaks of pneumonia, influenza, and bronchitis, and related to other morbidity effects, and is linked to pollen concentrations and high pollution levels. (See page ___.)

74b. Large increases in mortality have occurred during previous heat and cold waves. It is estimated that 1,327 fatalities occurred in the United States as a result of the 1980 heat wave, and Missouri alone accounted for over 25 percent of that total. (See page ___.)

74c. Hot weather extremes appear to have a more substantial impact on mortality than cold wave episodes. (See page ___.)

74d. Threshold temperatures, which represent maximum and minimum temperatures associated with increases in total mortality, have been determined for various cities. These threshold temperatures vary regionally; for example, the threshold temperature for winter mortality in mild southern cities such as Atlanta is 0°C and for more northerly cities such as Philadelphia, threshold temperature is -5°C. (See page ___.)

74e. If future global warming induced by increased concentrations of trace gases does occur, it has the potential to affect human mortality significantly. In one study, total summertime mortality in New York City was estimated to increase by over 3,200 deaths per year for a 7°F trace-gas-induced warming without acclimatization. If New Yorkers fully acclimatize, the number of additional deaths is estimated to be no different than today. It is hypothesized that if climate warming occurs, some additional deaths are likely to occur because economic conditions and the basic infrastructure of the city will prohibit full acclimatization even if behavior changes. (See page ___.)

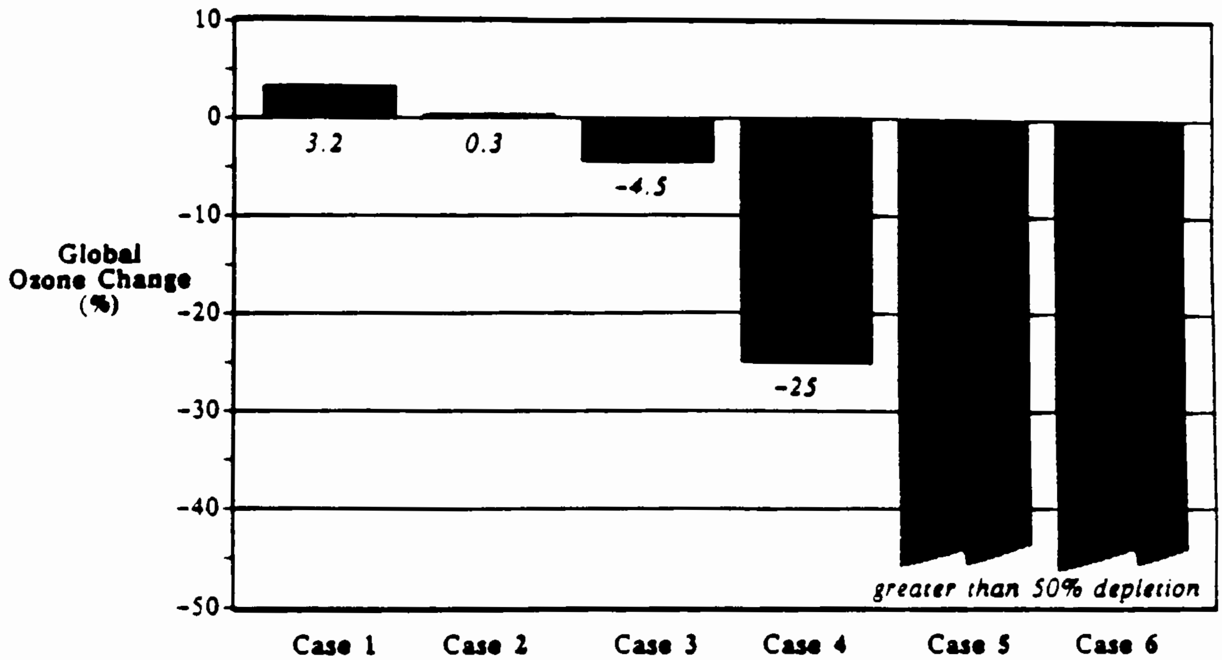
75. MODIFICATION OF THE TRACE GAS COMPOSITION OF THE ATMOSPHERE CAN BE EXPECTED TO ALTER COLUMN OZONE ABUNDANCE.

75a. The range of global average total column ozone change predicted for the year 2075 based on a parameterized representation of a one-dimensional model could vary from as high as over 50 percent depletion, for a case where global CFC use grows at an average annual rate of 2.8 percent from 1985 to 2100 (5.0 percent per year from 1985 to 2050, followed by no growth through 2100), to increased abundance of ozone of approximately 3 percent, for a case where global CFC use declines to 20 percent of its 1985 value by 2010. Exhibit ES-1 displays the global ozone change estimates for these two scenarios, as well as estimates for four scenarios in between; the six cases examined include:

(INSERT TO BE CUT AND TAPED)

EXHIBIT ES-1

ESTIMATES OF GLOBAL OZONE DEPLETION IN 2075
FOR SIX CASES OF CFC USE



Using a parameterized representation of a one-dimensional model, the potential change in ozone was evaluated for six cases: Case 1: global CFC use declines to 20 percent of current levels by 2010, and remains constant thereafter; Case 2: no growth in CFC use from current levels; Case 3: 0.7 percent annual average growth in CFC use from 1985 to 2100 (1.2 percent growth from 1985 to 2050, followed by no growth through 2100); Case 4: 1.4 percent annual average growth in CFC use from 1985 to 2100 (2.5 percent growth from 1985 to 2050, followed by no growth through 2100); Case 5: 2.1 percent annual average growth in CFC use from 1985 to 2100 (3.8 percent growth from 1985 to 2050, followed by no growth through 2100); Case 6: 2.8 percent annual average growth in CFC use from 1985 to 2100 (5.0 percent growth from 1985 to 2050, followed by no growth through 2100). The trace gas concentration assumptions used in these six cases are: CO_2: NAS 50th percentile; CH_4: 0.017 ppm per year (approximately 1 percent of current CH_4 concentration); and N_2O: 0.20 percent per year.

- Case 1: CFC use declines to 20 percent of its 1985 value by 2010, and remains constant thereafter, yielding approximately 3.0 percent increased ozone abundance by 2075;

- Case 2: no growth in CFC use from 1985 to 2100, yielding approximately 0.3 percent increased ozone abundance by 2075;

- Case 3: 0.7 percent annual average growth in CFC use from 1985 to 2100 (1.2 percent growth from 1985 to 2050, followed by no growth through 2100), yielding approximately 4.5 percent depletion by 2075;

- Case 4: 1.4 percent annual average growth in CFC use from 1985 to 2100 (2.5 percent growth from 1985 to 2050, followed by no growth through 2100), yielding approximately 25 percent depletion by 2075;

- Case 5: 2.1 percent annual average growth in CFC use from 1985 to 2100 (3.8 percent growth from 1985 to 2050, followed by no growth through 2100), yielding over 50 percent depletion by 2075;

- Case 6: 2.8 percent annual average growth in CFC use from 1985 to 2100 (5.0 percent growth from 1985 to 2050, followed by no growth through 2100), yielding over 50 percent depletion by 2075.

The trace gas concentration assumptions used in these six cases are: CO2 -- NAS 50th percentile; CH4 -- 0.017 ppm per year (approximately 1 percent of current CH4 concentration); and N2O -- 0.20 percent per year. (See page ____.)

75b. Current data are not sufficient for distinguishing whether CH4 concentrations are likely to increase in a linear manner (e.g, at 0.017 ppm per year, or approximately 1 percent of current concentrations) or in a compound manner (e.g., at 1 percent per year, compounded annually). The sensitivity of the ozone change estimates in 2075 was evaluated for the following six assumptions regarding future CH4 concentrations:

- M1: linear growth of 0.017 ppm per year (approximately 1 percent of current concentrations);

- M2: compound annual growth of 1 percent;

- M3: linear growth at 0.01275 ppm per year (75 percent of the 0.017 ppm growth);

- M4: linear growth at 0.02125 ppm per year (125 percent of the 0.017 ppm growth);

- M5: compound annual growth of 1 percent from 1985 to 2010, followed by constant concentrations at 2.23 ppm; and
- M6: compound annual growth of 1 percent from 1985 to 2020, growing to 1.5 percent compound annual growth by 2050 and thereafter.

For Case 4 of future CFC use, the estimate of ozone depletion by 2075 ranges from about 14 percent (M6) to 30 percent (M5) across these six CH_4 assumptions evaluated. For Case 2 of future CFC use, the range is from about 4.8 percent increase in ozone abundance (M6) to 2.0 percent depletion (M5). Exhibit ES-2 displays the results for the six CH_4 assumptions (M1 through M6) for Case 2 and Case 4. For Case 6, estimated ozone depletion exceeds 50 percent by 2075 under all six CH_4 assumptions (and is consequently not displayed in Exhibit ES-2). As shown in the exhibit, the difference between the 1 percent linear (0.017 ppm per year) and 1 percent compounded assumptions (M1 and M2) is approximately 6 percent depletion in Case 4 and approximately 2.5 percent change in ozone in Case 2. This sensitivity of the ozone depletion estimates to the assumption about linear versus compound growth of CH_4 concentrations is much larger than the sensitivity to the range of assumptions examined regarding future CO_2 concentrations (from the 25th to the 75th percentile NAS estimates) and regarding future N_2O concentrations (from 0.15 percent annual compound growth to 0.25 percent annual compound growth). (See page ____.)

76. TWO-DIMENSIONAL (2-D) MODELS PREDICT GREATER AVERAGE GLOBAL DEPLETION THAN ONE-DIMENSIONAL (1-D) MODELS. 2-D MODELS ALSO PREDICT THAT OZONE DEPLETION WILL EXCEED THE GLOBAL AVERAGE AT HIGH LATITUDES AND BE LESS THAN THE GLOBAL AVERAGE AT THE EQUATOR.

3% ↑ CFC's 0 Halons emiss. = 5.4% deplet. by 2030

76a. For a case of 3 percent annual growth in emissions of CFCs, no emissions of Halons, and increases in trace gases of: CO_2 -- approximately 0.6 percent per year; CH_4 -- 1 percent per year; and N_2O -- 0.25 percent per year, a 2-D model estimates approximately 5.4 percent global average depletion by 2030. For the same scenario of emissions and trace gas concentrations, the parameterized representation of a 1-D model estimates only 3.0 percent depletion by 2030. (See page ___.)

w/ latit'l diff's.

76b. For this same case of emissions and trace gas concentrations, the 2-D model estimates of ozone depletion in 2030 at high latitudes are approximately: 60°N -- 8.7 percent; and 50°N -- 7.0 percent. (See page ___.)

EXHIBIT ES-2

ESTIMATES OF GLOBAL OZONE DEPLETION IN 2075
FOR SIX METHANE CONCENTRATION ASSUMPTIONS
AND TWO CASES OF FUTURE CFC USE

(Cut and Tape)

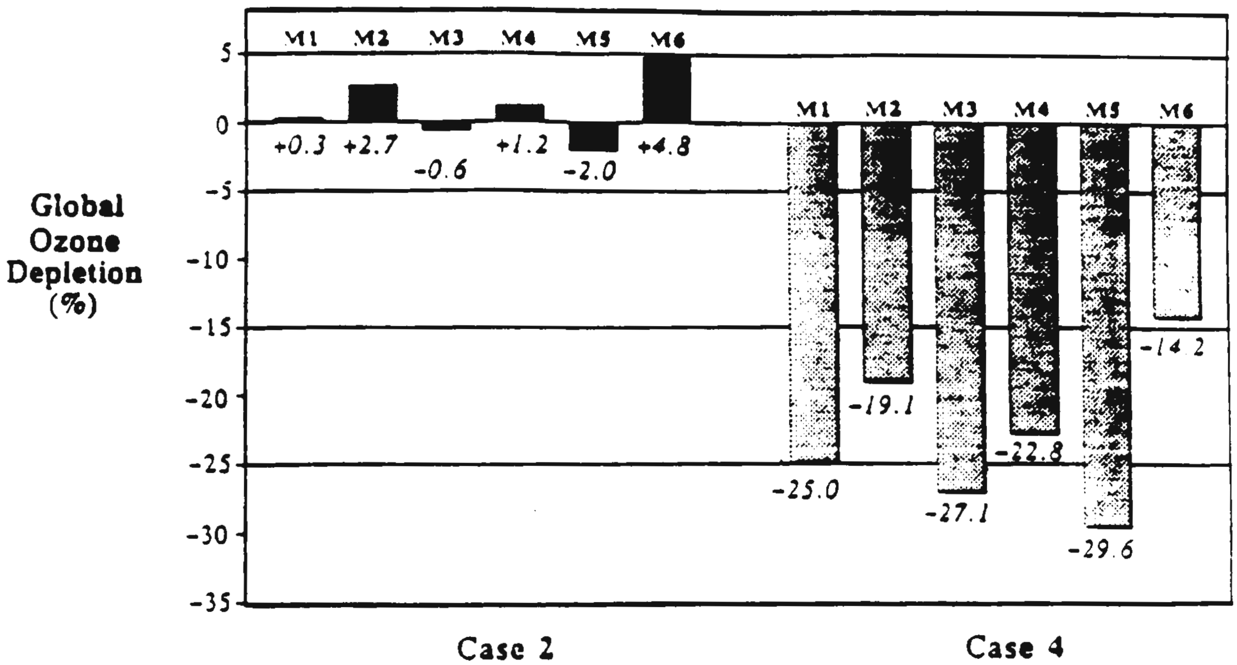
Using a parameterized representation of a one-dimensional model, the potential change in ozone was evaluated for six assumptions about future methane concentration: M1: linear growth of 0.017 ppm per year (approximately 1 percent of current concentrations); M2: compound annual growth of 1 percent; M3: linear growth at 0.01275 ppm per year (75 percent of the 0.017 ppm growth); M4: linear growth at 0.02125 ppm per year (125 percent of the 0.017 ppm growth); M5: compound annual growth of 1 percent from 1985 to 2010, followed by constant concentrations at 2.23 ppm; and M6: compound annual growth of 1 percent from 1985 to 2020, growing to 1.5 percent compound annual growth by 2050 and thereafter.

The two cases of future CFC use examined are: Case 2: no growth in CFC use 1985 to 2100; and Case 4: 1.4 percent annual average growth in CFC use from 1985 to 2100 (2.5 percent growth from 1985 to 2050, followed by no growth thereafter). The other trace gas assumptions used in these cases are: CO_2: NAS 50th percentile; and N_2O: 0.20 percent growth per year.

(INSERT TO BE CUT AND TAPED)

EXHIBIT ES-2

ESTIMATES OF GLOBAL OZONE DEPLETION IN 2075
FOR SIX METHANE CONCENTRATION ASSUMPTIONS
AND TWO CASES OF FUTURE CFC USE



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77. MODIFICATION OF TRACE GAS COMPOSITION OF THE ATMOSPHERE CAN BE EXPECTED TO CHANGE THE NUMBER OF SKIN CANCER CASES AND MORTALITIES OF PEOPLE CURRENTLY ALIVE OR PROJECTED TO BE BORN THROUGH THE YEAR 2075 AND BEYOND. FOR CASES OF HIGH GROWTH OF CFCs AND HALONS, THERE WILL BE SIGNIFICANT CANCER INCREASES. FOR THE CASE WHERE CFCs AND HALONS ARE SUBSTANTIALLY PHASED DOWN, SKIN CANCER INCIDENCE AND MORTALITY CAN BE EXPECTED TO DECREASE.

→ effects of scenarios on skin cancers

77a. Based on estimates of ozone change from a parameterized representation of a 1-D model, the increase in the number of cases of skin cancer among people alive today and born through 2075 may exceed 200 million for the highest emission case examined (Case 6: 2.8 percent annual average growth in CFC use from 1985 to 2100 [5.0 percent growth from 1985 to 2050, followed by no growth through 2100]). About 80 percent of these cases would be expected to occur after 2075. For the lowest emission case examined (Case 1: an 80 percent reduction in CFC use by 2010), a decrease in cancer cases on the order of 4.5 million is estimated. The overwhelming majority (over 95 percent) of the increases and decreases in skin cancer cases estimated for this wide range of emissions scenarios is associated with basal cell and squamous cell cancers. Mortality impacts are on the order of 1.5 to 2.0 percent of the changes in the numbers of cases, with squamous cell cancers producing the largest mortality impact due to the sensitivity of those types of cancers to UV-B increases. The estimated impacts are primarily associated with people born in the future. People alive today account for less than 5 percent of estimated increased cases, and people born between 1985 and 2030 account for about 20 to 30 percent. The remainder of the estimated impacts are accounted for by people born between 2030 and 2075. (See page ___.)

77b. The estimates of increased incidence vary on the order of 10 to 15 percent for the range of action spectra examined. (See page ___.)

77c. Statistical uncertainty regarding estimated dose-response coefficients influences the quantitative estimates of impacts. Additional uncertainties exist, some of which cannot be quantified. (See page ___.)

78. MODIFICATION OF THE TRACE GAS COMPOSITION OF THE ATMOSPHERE CAN BE EXPECTED TO INCREASE THE NUMBER OF CATARACTS.

78a. Based on estimates of ozone change from a parameterized representation of a 1-D model, the increase in the number of cases of cataracts among people alive today and born through 2075 may exceed 50 million for the highest emission case examined (Case 6: 2.8 percent annual average growth in CFC use from 1985 to 2100 [5.0 percent growth from 1985 to 2050, followed by no growth through 2100]). About 80 percent of these cases would be expected to occur after 2075. For the lowest emission case examined (Case 1: an 80 percent reduction in CFC use by 2010), a decrease in cataracts on the order of 2 million is estimated. The estimated impacts are primarily associated with people born in the future. People alive today account for about 5 to 10 percent of estimated increased cases, and people born between 1985 and 2030 account for about 30 percent. The remainder of the impacts are accounted for by people born between 2030 and 2075. (See page ___.)

78b. The estimates of increased incidence vary on the order of 10 to 15 percent for the range of action spectra examined. (See page ___.)

78c. Statistical uncertainty regarding estimated dose-response coefficients influences the estimates of impacts. Additional uncertainties exist, some of which cannot be quantified. (See page ___.)

79. MODIFICATION OF THE TRACE GAS COMPOSITION OF THE EARTH CAN BE EXPECTED TO RAISE THE GLOBAL EQUILIBRIUM AND ACTUAL TEMPERATURE OF THE EARTH.

temp ↑'s!

79a. The equilibrium temperature increase by the year 2075 estimated using a one-dimensional model varies significantly across the six cases of CFC use examined (see above). For Case 6, in which CFC use grows at an average annual rate of 2.8 percent from 1985 to 2100 (5% before 2050; 0% thereafter), equilibrium temperatures could rise about 11.5°C from temperatures observed in 1985. For Case 1, in which CFC use decreases by 80 percent by 2010, equilibrium temperatures could rise about 2°C. The climate sensitivity to doubled CO2 is assumed to be 3°C for these estimates, and the growth in other trace gas concentrations used was: CO2: NAS 50th percentile; CH4: 0.017 ppm per year; and N2O: 0.20 percent per year. Higher rates of growth in other trace gases result in larger estimates of warming. The National Academy of Sciences has suggested that the uncertainty associated with these types of estimates is 1.5°C to 4.5°C. (See page ___.)

79b. Sea level would be expected to rise with this warming. By 2075, thermal expansion and alpine melting may contribute between 35 cm and 80 cm under the above assumptions. Glacial contributions are particularly uncertain (particularly from Antarctic glaciers) and may be between 20 cm and 110 cm by 2075, for a total rise of 55 cm to 190 cm. (See page ___.)

80. WHILE QUANTITATIVE ESTIMATES OF AQUATIC, CROP, GROUND-BASED OZONE, AND SEA LEVEL RISE DAMAGE CANNOT BE MADE AT THIS TIME, CASE STUDY RESULTS INDICATE THAT SIGNIFICANT ADVERSE IMPACTS ARE POSSIBLE.

☆ case studies

80a. According to a single study of possible changes in tropospheric ozone in urban areas, a 33 percent ozone depletion could cause peak ozone values to rise about 50 percent in Nashville, about 9 percent in Los Angeles, and about 33 percent in Philadelphia. Three of the six cases of CFC use examined could result in ozone depletion of this order of magnitude. Care should be taken in interpreting these studies, and additional research is needed to assess these results. (See page ___.)

80b. The results of a case study suggest that northern anchovies could be harmed by ozone depletion. Laboratory studies indicate that under some conditions, as small as a 10 percent increase in UV-B could have an adverse influence on anchovy mortality. A 30 percent increase in UV-B could increase mortality by 0 to 10 percent, and a 60 percent increase in UV-B could increase mortality by 11 to 25 percent. Three of the six cases of CFC use examined could result in UV-B increases of this order of magnitude. Care should be taken in interpreting these studies, and additional research is needed to assess these results. (See page ___.)

80c. Field experiments on the Essex cultivar of soybeans indicate that a 25 percent ozone depletion could reduce yields by up to 25 percent. Actual damages might be somewhat lower if existing UV-resistant cultivars become preferred. Additional study is required to better assess the potential impacts of UV-B on crops. (See page ____.)

80d. Based on a case study of the economic impacts of sea level use, the potential economic impact of a 55- to 190-cm rise by 2075 on the two U.S cities studied is on the order of $400 million to $3.7 billion (present value, 1980 dollars). The magnitude of impact is sensitive to assumptions regarding whether and how people prepare for future sea level rise. Additional studies are required to confirm the magnitude of these estimates, and to develop estimates for the total U.S. impact. (See page ____.)

HISTORY OF PRIOR ASSESSMENTS OF THIS ISSUE

A number of prior assessments of stratospheric modification and climate change have been done. A partial list with descriptions is included below:

STRATOSPHERIC OZONE

1. National Academy of Sciences (NAS), 1975, 1976, 1979, 1982, 1983

Several assessments of anthropogenic influences on the stratospheric ozone layer were coordinated by the National Academy of Sciences. The first report, in 1975, focused on the effects of proposed fleets of supersonic transports on the stratosphere. Subsequent reports focused on chlorofluorocarbons.

2. National Aeronautics and Space Administration (NASA), 1977, 1986

NASA has convened several technical panels to review models and chemistry. In addition, it completed a scientific assessment in 1986.

3. World Meteorological Organization,
National Aeronautics and Space Administration,
Federal Aviation Administration,
National Oceanic and Atmospheric Administration,
United Nations Environment Programme,
Commission of the European Communities, and
Bundeministerium fur Forschung und Technologie

International assessments of the stratosphere have been conducted by the European Community, the United Kingdom's Department of the Environment (1979), and by the United Nations Environment Coordinating Committee on the Ozone Layer (1981, 1984, 1986).

The most recent and most ambitious assessment of the scientific issues regarding the stratosphere was coordinated by the World Meteorological Organization with the assistance of several other organizations. Approximately 150 of the world's leading scientists participated in this assessment.

CLIMATE

1. Climatic Impact Assessment Program, 1974

Initial concern over anthropogenic influences on the climate and the stratospheric ozone layer led in 1971 to the establishment of the Climatic Impact Assessment Program (CIAP). Coordinated by the Department of Transportation, CIAP's objective was to assess, by a report in 1974, the impacts of climatic changes due to projected fleets of supersonic transports.

2. National Academy of Sciences: 1979, 1982, 1983

Three panels were convened by the National Academy of Sciences to assess the scientific basis and certainty of the effects of carbon dioxide concentrations on global climate. Reports were released in 1979, 1982, and 1983.

3. World Meterological Organization,
International Council of Scientific Unions, and
United Nations Environment Programme

Efforts to achieve an international scientific consensus on carbon dioxide, trace gases, and climate were coordinated by the World Meterological Organization (WMO), International Council of Scientific Unions (ICSU), and United Nations Environment Programme (UNEP). Assessments were released in 1979, 1981, and 1985.

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OMB OZONE STATE-OF-SCIENCE BRIEFING

WASHINGTON, D.C.
3 APRIL 1987

DAN ALBRITTON
NOAA AERONOMY LAB

A FOCUS ON:

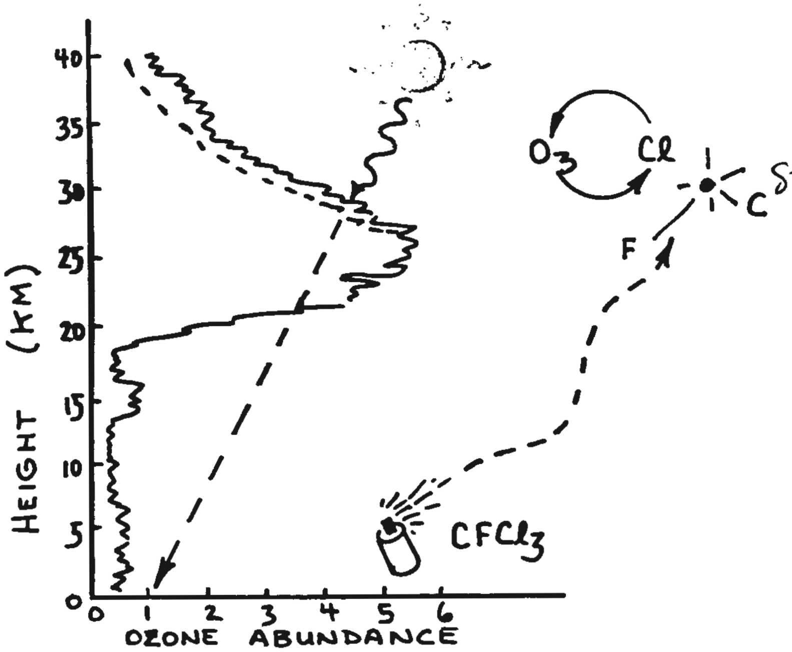
- GLOBAL OZONE MONITORING
- ANTARCTIC OZONE "HOLE"

FOR EACH ...

- WHERE DOES IT FIT IN? (A LITTLE BACKGROUND)
- WHAT HAS BEEN/IS BEING DONE? (RESEARCH APPROACHES)
- WHAT DO WE KNOW & DON'T KNOW NOW? (SPRING '87 BOTTOM LINES)
- WHAT ARE THE "NEXT-STEP" PLANS? (POSSIBLE NEW INSIGHTS BY FALL '87)

BACKGROUND

- **ISSUE:** MAN-MADE CHLORINE CHEMICALS MAY BE DEPLETING THE OZONE LAYER



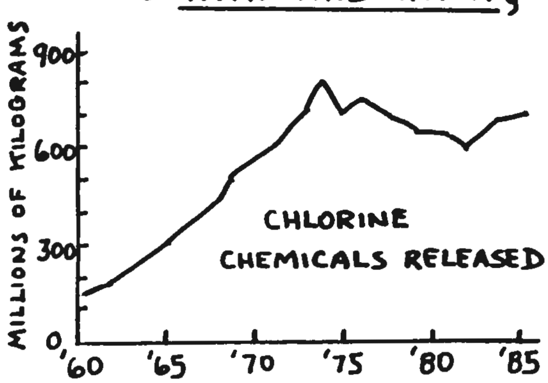
Sun breaks down the chlorine compounds into chlorines which destroy ozones.

PROPOSED ~1974

- **SCIENCE STATUS:**

CURRENT THEORY PREDICTS...

- WITH THIS INPUT,



- THE ATMOSPHERE WILL RESPOND BY...

1987: 0-1% GLOBAL OZONE LOSS

RANGE OF EMISSION SCENARIOS

2017: 0 - 2½ %

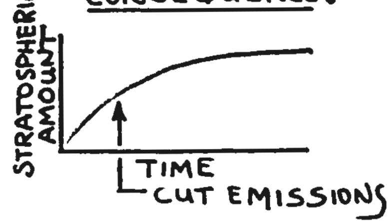
2047: 0 - 4%

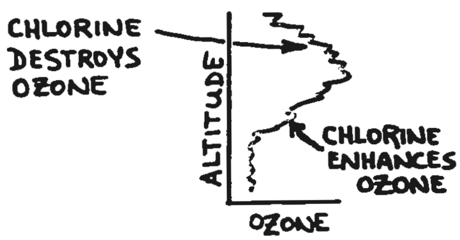
- **RESEARCH FOCI:** ① WHAT IS THE UNCERTAINTY IN THESE PREDICTIONS?

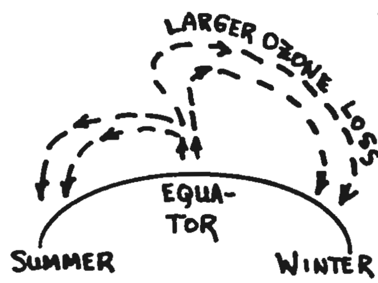
  ② HAVE WE SEEN THE 1% YET?

↳ even if we cut emissions, stratospheric concen's will contin to increase

THE THEORETICAL PICTURE: SHARPENING THE FOCUS

EXAMPLE:	APPROACH:	CONSEQUENCE:
• ESTABLISHING THE ATMOSPHERIC LIFETIMES OF THE CFC'S	MONITOR TRENDS + KNOWN EMISSIONS = LIFETIME	
• LABORATORY MEASUREMENT OF CHEMICAL REACTION RATES	NEW WAYS TO DETECT CHEMICAL SPECIES, E.G., LASERS	NEW DATA FOR $HO_2 + NO$... PREDICTED OZONE LOSS } 2 → 4%
• MEASURE STRATOSPHERIC ABUNDANCE OF OZONE-RELATED SPECIES		OBSERVATIONS MATCH PREDICTIONS FOR SEVERAL SPECIES: CONFIDENCE: ⬆
• 2-D THEORY OF CHLORINE-INDUCED OZONE LOSS BY LATITUDE		MORE OZONE LOSS PREDICTED AT THE HIGHER LATITUDES: E.G.: 6% 60°N, 3% EQUATOR





→ ozone losses will differ by latitude

→ seasonal dependence & latit'l depen.

CURRENT BOTTOM LINE:

IF CHLORINE EMISSIONS CONTINUE UNABATED INDEFINITELY, THEN THE PRESENT UNDERSTANDING IMPLIES THAT <u>SUBSTANTIAL OZONE DEPLETIONS WILL OCCUR EVENTUALLY</u>, PARTICULARLY AT THE <u>HIGHER ALTITUDES</u> & <u>HIGHER LATITUDES</u>.

GLOBAL OZONE MONITORING

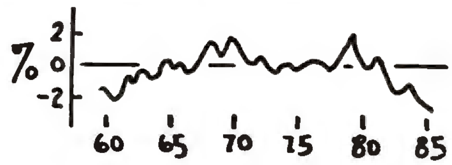
EXAMPLE / CONSEQUENCE

- GROUND-BASED "DOBSON" NETWORK:
  - DOZENS
  - ~ FEW DECADES

(total amt ozone above of the gd-based monitor)
(not measure distrib)

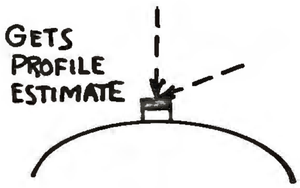
NATURAL VARIATION

global avg ozone behav as measure'd by Dobson

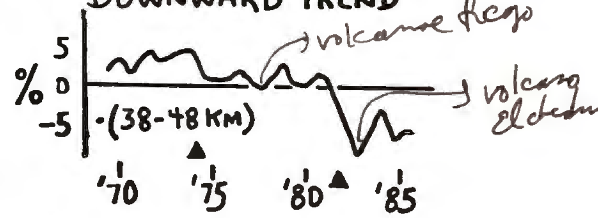


- "UMKEHR" NETWORK (VARIATION OF DOBSON)

(height distrib's)



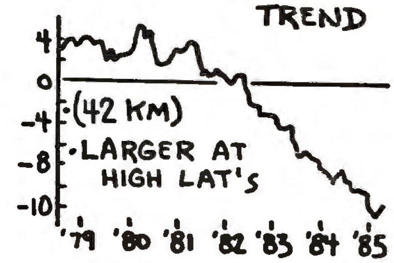
DOWNWARD TREND



- SBUV SATELLITE
  NASA: 1978 - NOW
  NOAA: RECENT LAUNCH

[theory says chg's shld occur at high alt's first)

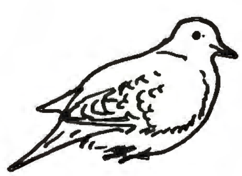
DISTINCT DOWNWARD TREND



CURRENT BOTTOM LINE(S):

- UMKEHR & SBUV SHOW DEPLETIONS AT THE
  - ALTITUDES
  - LATITUDES

  PREDICTED BY THE CHLORINE-INDUCED THEORY
- IT'S EVEN BIGGER THAN THEORY! ∟2-3 X's lrger



no chg in global ozone by Dobson

- DOBSON IS A VENERABLE INSTRUMENT; TRUST IT
- UMKEHR IS SENSITIVE TO VOLCANIC ▲ DUST
- SATELLITE SENSOR-DRIFT IS HARD TO CORRECT (measurements may ~ be accur.)
- 6-7 YRS IS A SHORT TIME TO GET A SOLID TREND

- FUTURE PLANS FOR THIS YEAR!

> INDEPENDENT EVALUATION OF THE EXISTING DOBSON, UMKEHR, & SATELLITE DATA. } Watson's Team

- TEAM: 4 NASA
  2 NOAA
  2 INDUSTRY
  8 UNIVERSITY
  PLUS REQUESTED SUPPORTERS

- ADDRESS INCONSISTENCIES
  REANALYZE DATA
  INTERCOMPARE IN DETAIL
  RE-ESTIMATE UNCERTAINTIES
  PULL WHOLE PICTURE TOGETHER

- STATEMENT READY IN LATE FALL, 1987

(1) Will say whether ozone has chg'd or not

(2) will address inconsistencies

(3) no defin answer on cause/effect
  L yet will know if chlorine is cause, yet not have global implic's

ANTARCTIC OZONE "HOLE"

- **ISSUE:** – THERE IS NO QUIBBLING HERE ABOUT THE REALITY OF A FEW PERCENT;
  ~HALF OF THE OZONE OVER ANTARCTICA HAS DISAPPEARED (IN A VERY CURIOUS FASHION)

  – IT WAS TOTALLY UNANTICIPATED (WHICH IS RATHER UNSETTLING).

- **OBSERVATIONS:**

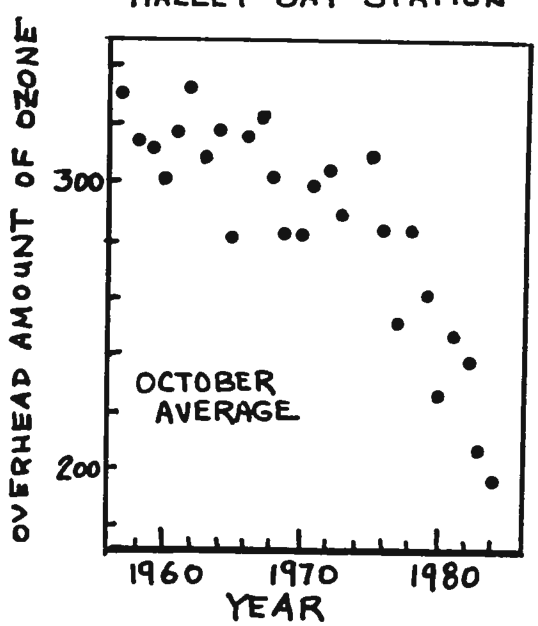
  noticed & announced in —

  BRITISH ANTARCTIC SURVEY, "DOBSON" DATA (JULY, 1985)

  – SINCE ABOUT ~1965, (really ~72-73)
  – IN THE ANTARCTIC SPRING,
  – (AND ONLY IN THE SPRING), (not yr. rd. loss)
  – OVERHEAD OZONE HAS TENDED TO DECREASE,
  – MORE & MORE EACH YEAR.
  magnitude of decrease is ↑'g.

50% of ozone disappears in October & then reappears.

HALLEY BAY STATION



DEC, 1985: CONFIRMED ☑
- SATELLITE
- BALLOON-BORNE OZONESONDE
- OTHER DOBSONS

- **WHAT IS THE CAUSE?** (EARLY IN 1986)

  THERE ARE A LOT OF THEORIES...

  - **CHLORINE/BROMINE INCREASE**

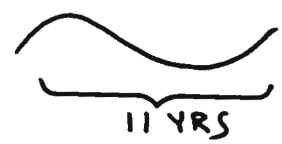
    THE PREVIOUS 2-D CHLORINE/OZONE THEORY CANNOT EXPLAIN IT

    BUT: - THE ANTARCTIC STRATOSPHERE IS EXTREMELY COLD,
    - THERE ARE A LOT OF ICE CLOUDS,
    - ICE MAY FREE MORE REACTIVE CHLORINE,
    HENCE, $Cl-O_3$ LOSS MAY BE ACCELERATED.

  - **SUNSPOT CYCLE**

    - SOLAR PARTICLES MAKE REACTIVE NITROGEN SPECIES,
    - NITROGEN ACCUMULATES AT POLE & ACCELERATES O_3 LOSS,

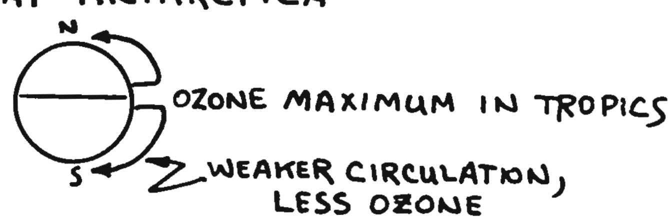
    HENCE, PRESENT TREND IS PART OF SUNSPOT CYCLE AND WILL REVERSE



  - **CLIMATE CHANGE**

    - SLOWLY CHANGING CIRCULATION PATTERNS MEAN MORE OZONE-POOR AIR AT ANTARCTICA

    FOR EXAMPLE:



    - SLOWLY CHANGING UPWARD WINDS DURING SPRING BRING OZONE-POOR AIR FROM TROPOSPHERE INTO STRATOSPHERE

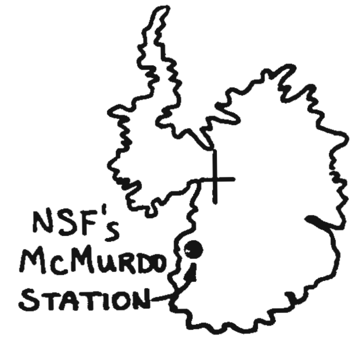
  - **AND NUMEROUS OTHERS & VARIANTS**

    BUT, WHICH ONE(S) IS CORRECT? A DATA-SHORT SITUATION!

• NOAA "OZONE-HOLE" RESEARCH: CURRENT & FUTURE

MAJOR INVOLVEMENT IN NATIONAL OZONE EXPEDITION SUMMER, 1986

- SUPPORTED BY NSF, NASA, NOAA, & INDUSTRY
- ~20 SCIENTISTS
  - NOAA AERONOMY LAB
  - JET PROPULSION LAB
  - U. OF WYOMING
  - STATE U. OF NEW YORK



JULY–NOVEMBER

- SHORT NOTICE, HENCE LARGELY EXISTING GROUND-BASED APPARATUS
- YET NEARLY ALL APPARATUS WORKED AS PLANNED (REMARKABLE!)
- OBSERVATIONS
  - PRE-"HOLE"
  - OZONE MINIMUM
  - RECOVERY

  ~1 DOZ. SPECIES
  - OZONE
  - CHLORINE
  - NITROGEN

  ⋮
- NOT ALL DATA ARE FULLY ANALYZED
- RESULTS TO DATE:
  - OZONE ~40% LOSS } hole occurred again -- (not quite as big but not smaller)
  - CHLORINE GREATLY ENHANCED → * inpt.
  - NITROGEN VERY LOW ↓ compared to other places on globe

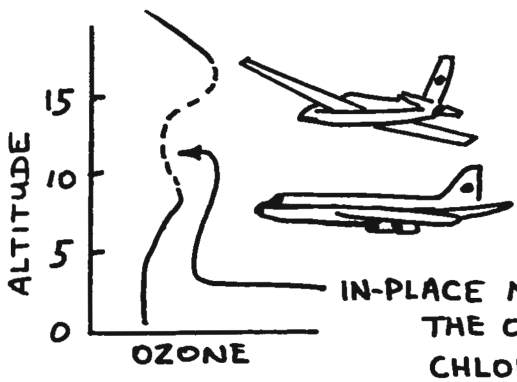
➡ CURRENT BOTTOM LINE:

THEORIES:	AFTER 1986 EXPEDITION:
• MAN-MADE CHLORINE	– MORE LIKELY
• SOLAR CYCLE	– LESS LIKELY
• CLIMATE CHANGE	– MAYBE PLAYS A ROLE

* – the depth is increasing over time -- not getting larger.

1987 AIRBORNE OZONE-HOLE CAMPAIGN

- SPONSORED BY NASA, NOAA, & CHEM. MANUFACT. ASS'N.
- JULY – SEPT, 1987 MISSION
- 2 NASA AIRCRAFT: ER-2 & DC-8
- ~30 SCIENTISTS
  - 12 NOAA
  - 10 NASA
  - 8 UNIVERSITY



IN-PLACE MEASUREMENTS WHERE THE OZONE LOSS IS OCCURRING: OZONE, CHLORINE, BROMINE, NITROGEN, ···

1987 GROUND-BASED OZONE-HOLE CAMPAIGN

- BEING ORGANIZED NOW
- SPONSORED BY NSF, NOAA, NASA THUS FAR
- ADDITIONAL EXPERIMENTS – NSF WILL SUPPLY <u>TWO</u> FERRY FLIGHTS
- WIDER OZONE MEASUREMENTS

BETTER 3-D PICTURE

PROSPECTS?

OZONE-RELATED CHEMICALS OBSERVED:

≤1985	1986	1987
1 or 2	~6 "looking up"	~30 * in-situ & looking up

∴ A <u>SUBSTATIALLY IMPROVED</u> STATEMENT REGARDING { ☐ HUMAN-CAUSED ☐ NATURAL

SUMMARY

- **THE FUTURE:** (THEORY)

  GLOBAL OZONE

  - IF STRATOSPHERIC CHLORINE CONTINUES TO INCREASE, THEN THE PRESENT UNDERSTANDING IMPLIES SUBSTANTIAL OZONE LOSSES EVENTUALLY, PARTICULARLY AT HIGHER LATITUDES.
  - IT IS A QUESTION NOW OF HOW MUCH AND WHEN.

- **THE PRESENT:** (OBSERVATIONS)

  GLOBAL OZONE

  - EXISTING SATELLITE & GROUND-BASED DATA ARE INCONSISTENT.
  - INTERPRETATIONS RANGE FROM {
    - NO OBVIOUS HUMAN-CAUSED TRENDS
    - MARKED DOWNWARD TRENDS, 2-3X LARGER THAN THEORY
  - AN INDEPENDENT REVIEW IS UNDERWAY (~ NOV. 1987)

  ANTARCTIC OZONE HOLE

  - IT IS REAL! ~50% SEASONAL OZONE DEPLETION
  - SEVERAL HYPOTHESES AS TO CAUSE:
    - MAN-MADE CHLORINE
    - SOLAR CYCLE
    - CLIMATE CHANGE
  - 1986 OBSERVATIONS:
    - CHLORINE HIGH, NITROGEN LOW.
    - [CONSISTENT WITH (BUT NOT PROOF OF) MAN-MADE CHLORINE HYPOTHESIS]
  - SINCE CAUSE IS NOT ESTABLISHED, THE GLOBAL IMPLICATIONS ARE UNKNOWN CURRENTLY.
  - SUBSTANTIAL ( & $) MULTI-AGENCY EFFORT IN SUMMER 1987.

Proposed Rules

Federal Register
Vol. 51, No. 7
Friday, January 10, 1986

This section of the FEDERAL REGISTER contains notices to the public of the proposed issuance of rules and regulations. The purpose of these notices is to give interested persons an opportunity to participate in the rule making prior to the adoption of the final rules.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Food and Drug Administration

21 CFR Part 163

[Docket No. 85N-0500]

Cocoa Powders; Advance Notice of Proposed Rulemaking on the Possible Amendment of U.S. Standards of Identity

Corrections

In FR Doc. 85-28351 beginning on page 49405 in the issue of Monday, December 2, 1985, make the following corrections:

1. On page 49406, in the third column, in the eleventh line from the bottom, "§ 163.11" should read "§ 163.111";

2. On page 49407, in the second column, in the table, under "4. Food Additives", the second entry should read "4.1.2 Ammonium hydrogen carbonate";

3. On the same page, in the third column, in the table, under "5. Contaminants", the third entry should read "5.3 Lead";

4. On page 49408, in the second column:

a. In the second line of 8.4(b), "1974" should read "1973";

b. After entry 8.7, add the following entry:

8.8 *Determination of sugars* (to be elaborated)[1]

c. The footnote indicators immediately following the headings of entries 8.10 and 8.11 should both be changed to "2";

d. In the second line of the paragraph following entry 8.11, "test" should read "text"; and

5. On page 49409, in the first column, the fourth line of § 163.114 should be deleted.

BILLING CODE 1505-01-M

21 CFR Part 163

[Docket No. 85N-0501]

Chocolate Products; Advance Notice of Proposed Rulemaking on the Possible Amendment of the U.S. Standards of Identity

Correction

In FR Doc. 85-28350 beginning on page 49398 in the issue of Monday, December 2, 1985, make the following correction:

On page 49404, in the third column, in the second and third lines of § 163.145(a), "are prescribed by this identity" should be deleted.

BILLING CODE 1505-01-M

DEPARTMENT OF TRANSPORTATION

Coast Guard

33 CFR Part 166

[CGD 85-097]

Port Access Routes; Approach to Tampa Bay, FL

Correction

In FR Doc. 85-29476, beginning on page 50808 in the issue of Thursday, December 12, 1985, make the following correction: On page 50809, in the second column, in the table of geographic positions, the fourth entry under "Longitude" should read "83°05′06″ W."

BILLING CODE 1505-01-M

POSTAL SERVICE

39 CFR Part 111

Correct ZIP Codes for Mailing; Withdrawal of Proposed Rule

AGENCY: Postal Service.

ACTION: Withdrawal of proposed rule.

SUMMARY: On March 19, 1985 the Postal Service published in the **Federal Register** (50 FR 10991) a proposal to require mailers of certain categories of mail and those who desire to participate in certain presort discount mailings to include a correct five-digit ZIP Code, as defined by certain Postal Service data bases, in the address of each piece. Less than a dozen commenters responded to the proposal. However, the substance of their views was that the proposal contained certain latent ambiguities. In view of these comments, the Postal Service is hereby withdrawing the proposal for further consideration, with the expectation that it may be initiated at a later time

DATE: This withdrawal is effective January 10, 1986.

FOR FURTHER INFORMATION CONTACT: William Price, (202) 268-3521.

List of Subjects in 39 CFR Part 111

Postal Service.

W. Allen Sanders,
Associate General Counsel, Office of General Law and Administration.

[FR Doc. 86-527 Filed 1-9-86; 8:45 am]

BILLING CODE 7710-12-M

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Ch. I

[OAR-FRL-2949-3]

Stratospheric Ozone Protection Plan

AGENCY: Environmental Protection Agency.

ACTION: Announcement of Program Plan.

SUMMARY: This notice describes recent activities related to protection of the stratospheric ozone layer and outlines EPA's program plan for future examination of the issue. By enhancing EPA's research and analysis related to stratospheric ozone protection, this program will provide necessary technical information for use in future Agency decisions on whether or not to regulate chlorofluorocarbons (CFCs) or other chemicals that may affect the ozone layer. In addition, the plan places considerable emphasis on United States participation in on-going international research and discussions of global strategies for protecting the ozone layer.

This notice provides a broad outline and general schedule for the stratospheric ozone protection program. Throughout the implementation of this program, EPA encourages public review and participation. Where appropriate, the Agency will announce in the **Federal Register** upcoming workshops and conferences and the availability of papers for review.

FOR FURTHER INFORMATION CONTACT: Stephen Seidel, U.S. Environmental Protection Agency, 401 M St. S.W., Washington, D.C. 20460 (202) 382-2787.

SUPPLEMENTARY INFORMATION:

Background

By preventing most potentially harmful ultraviolet radiation (UV-B radiation) from penetrating to the earth's surface, the ozone layer acts as an important shield protecting human health, welfare and the environment. The possibility that the production, use, and release of chlorofluorocarbons (CFCs) could cause the depletion of stratospheric ozone was first theorized in a 1974 article in *Nature* by Rowland and Molina. If a net depletion of total-column ozone (i.e., the total quantity of ozone encountered by radiation penetrating from the top of the atmosphere to the earth's surface at any given location) occurred, more UV-B radiation would penetrate to the earth's surface.

Possible health and environmental effects of exposure to increased UV-B radiation could include: increases in non-melanoma skin cancer; suppression of the human immune system; decreases in the productivity of commercially important crops and aquatic organisms; and accelerated degradation of polymeric materials. In addition, EPA and the National Institutes of Health have recently initiated studies to determine whether or not exposure to UV-B radiation can contribute to melanoma skin cancer. Finally, production and use of CFCs may contribute to the predicted global warming from the "greenhouse effect" through two pathways. First, changes in the distribution of total-column ozone could possibly increase temperature, and second, CFCs themselves are infrared-absorbing gases that act directly (in the same manner as carbon dioxide) to raise global surface temperature.

Although less was known about the possible causes and effects of ozone depletion in the mid-1970's, EPA and other agencies responded to concerns about this issue by promulgating regulations in 1978 limiting the use of CFCs as a propellant in nonessential aerosol spray cans (43 FR 11301; March 17, 1978). CFC use as an aerosol propellant had grown to 56 percent of total CFC use in this country and 25 percent of total world consumption in 1974. By significantly reducing CFC use and therefore the risks of ozone depletion, this action has provided more time to address the complex scientific questions involved in assessing those risks.

While several other countries also acted to limit CFC use in aerosol propellants, this use continues in most countries. In addition, CFCs are used here and abroad for many important industrial and commercial processes, including refrigeration, air conditioning, and foam blowing, and as a solvent by the electronics industry.

In 1980 EPA issued an advance notice of proposed rulemaking discussing possible further limits on domestic production of CFCs under section 157 of the Clean Air Act, 42 U.S.C. 7457 (45 FR 66726; Oct 7, 1980). However, some of the scientific information summarized in that notice was soon outdated by more recent work in the field, and there have been substantial changes in the research community's understanding of several important aspects of the issue since then. In general, the more recent work has demonstrated that possible changes in the ozone layer are affected by a more complex array of physical and chemical forces than previously thought, and that substantial uncertainties remain to be resolved before such changes can be predicted with confidence. In addition, EPA believes that any decision on further regulation of domestic CFC production or use must be based on further research and analysis, and should be evaluated in the context of possible international regulatory actions. Today's notice outlines the Agency's current plan for further examination and resolution of this issue.

Two current areas of activity set the context in which EPA is acting. Both scientific and diplomatic efforts are underway, and each figures significantly in the Agency's plan. First, the scientific research community has expanded its efforts to improve our understanding of the physical and chemical forces that affect the ozone layer and how these may change over time. For example, researchers now recognize that atmospheric constituents other than CFCs have been increasing, and that future changes in these substances must also be considered in modelling the future evolution of the atmosphere. Researchers have also placed additional emphasis on the potential climatic impacts that might be caused by changes in atmospheric chemical composition.

Several major reports on related scientific issues are planned for the next year. A major review of atmospheric science issues related to ozone modification is scheduled to be published in January 1986. This report is being sponsored by the National Aeronautics and Space Administration (NASA), the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), and other national and international organizations. NASA is also preparing a companion report to EPA and Congress on this subject. UNEP's Coordinating Committee on the Ozone Layer will hold meetings in 1986 and will issue a report that covers atmospheric science and other areas of research related to the effects of exposure to UV-B radiation on human health, welfare and the environment. The Fluorocarbon Program Panel of the Chemical Manufacturers Association (CMA) continues to fund research primarily related to ozone monitoring and atmospheric modelling. Finally, in October 1985, the WMO convened a conference in Villach, Austria to examine potential changes in climate that could, in part, result from increases in CFCs and other ozone-modifying substances and from changes in the vertical distribution of ozone.

The second major focus of recent activities has centered on international negotiations concerning protection of the ozone layer. Conducted under the auspices of UNEP, these negotiations resulted in the adoption of the Vienna Convention for the Protection of the Ozone Layer in March 1985. This convention creates a framework for international cooperation on research, monitoring and information exchange. It also provides procedures for the future adoption of measures to control, limit, prevent or reduce emissions of ozone-modifying substances, should such measures be deemed necessary. This treaty comes into force after formal acceptance by twenty nations.

While successfully adopting the framework convention, the Diplomatic Conference in Vienna failed to agree on any appropriate global control measures. In lieu of such measures, it passed a resolution calling for an economic workshop to analyze relevant aspects of control options and for continued negotiations culminating in a second Diplomatic Conference currently planned for April 1987.

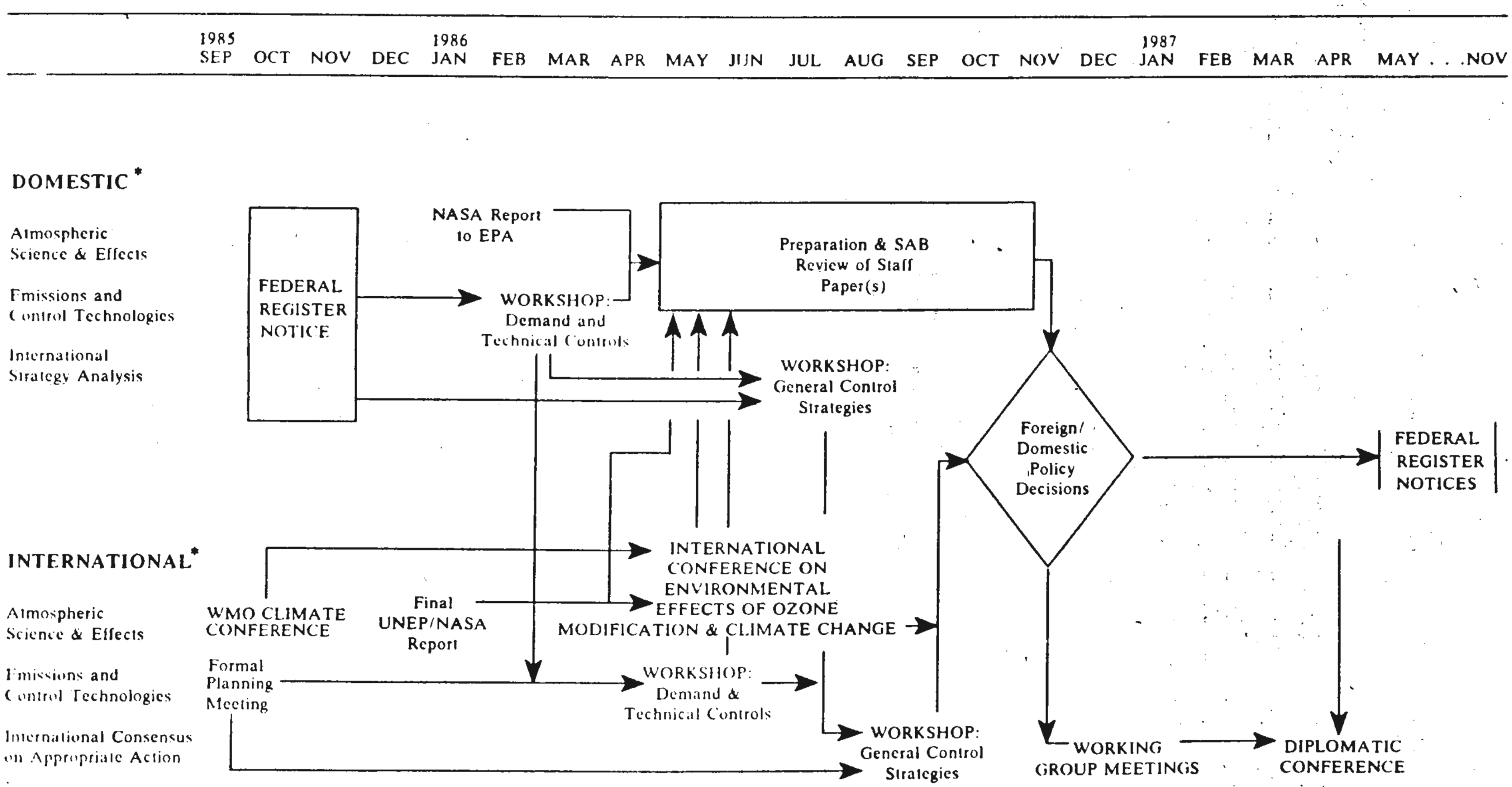
Program Plan

EPA's stratospheric ozone protection program integrates the diverse scientific and economic research being carried on by EPA and by other organizations into a coherent framework for future Agency decisionmaking on both the domestic and international aspects of this issue. (See Figure 1.) Three primary elements of the Agency's program are: (1) conducting analyses and research across a range of economic and scientific subjects aimed at narrowing uncertainties; (2) participating in a series of workshops and conferences both in the United States and abroad aimed at improving understanding of all aspects of this issue; and (3) deciding by November 1987 whether additional domestic regulation of CFCs is warranted, based on the information gained during the period of study.

BILLING CODE 6560-50-M

Figure 1

ACTIVITIES RELATED TO EPA'S STRATOSPHERIC OZONE PROTECTION PROGRAM



* STUDIES ONGOING IN ALL CATEGORIES TO SUPPORT MAJOR EVENTS

BILLING CODE 6560-50-C

Key areas for analysis include: evaluating potential future rates of growth in emissions; modelling the changes to the ozone layer that may result from changes in the atmosphere's composition; analyzing model parameters and predictions in light of atmospheric monitoring data; evaluating potential health, welfare and environmental effects from exposure to increased UV–B radiation or changes in climate related to ozone modification; and analyzing potential economic impacts, including the potential benefits from limiting UV–B exposure and the potential costs of limiting future increases in CFCs and other atmospheric perturbants.

Analysis of *future demand for CFCs and other atmospheric perturbants* and the *costs and feasibility of emission reduction technologies* will be subject of a domestic workshop scheduled for March 1986 and a UNEP-sponsored international workshop scheduled for May 1986.

Analysis of issues related to the *measurement and modelling of atmospheric changes* will be based on the NASA/UNEP report scheduled to be available in January 1986, a planned companion report to be prepared for EPA and Congress by NASA and the results from on-going studies being conducted or funded or NASA, CMA's Fluorocarbon Program Panel, the National Oceanic and Atmospheric Administration and others.

Analysis of *potential health, welfare and environmental effects* from increased exposure to UV–B will draw from on-going research being funded by EPA in the areas of plant and aquatic effects, human health effects, materials damage, and climate impact assessments. Results of this research, along with that sponsored by other organizations, will also be used by UNEP's Coordinating Committee on the Ozone Layer for part of its report, scheduled for publication in 1986. In addition, the United States and UNEP are jointly sponsoring an international conference on health and environmental effects related to ozone depletion and climate change. This conference is now set for mid-June 1986 in Washington, D.C.

EPA is also planning to convene a workshop to evaluate *alternate global and domestic control strategies*, tentatively set for July 1986. This domestic workshop will be followed by a UNEP-sponsored international workshop on the same issue now scheduled for September 1986. These two workshops set the stage for resumption of international negotiations concerning a control protocol scheduled to begin in November 1986.

EPA, in conjunction with the Department of State, plans to prepare an environmental impact statement pursuant to Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions," in the event that a protocol is adopted.

A more detailed discussion of specific studies and research to be used for these activities is available to the public by contacting Mr. Stephen Seidel at the address provided above.

Decisionmaking Process

Research and analyses prepared as part of EPA's program plan or developed by other sources will be integrated into one or more staff papers that will serve as the basis for future Agency decisionmaking. EPA intends to make these staff papers available for review by the public and by its Science Advisory Board. The final staff papers will serve as the technical basis for any regulatory decisions.

At the same time, EPA will continue to participate actively in the ongoing UNEP workshops and will provide support to the Department of State in negotiations concerning possible global strategies to protect the ozone layer. Because of the global nature of this issue, any decision concerning future domestic regulatory actions will be evaluated in the context of ongoing international negotiations.

By May 1987, EPA plans to issue a Federal Register notice summarizing the results of its program and either proposing further regulation related to this issue or presenting the basis for a proposed decision to take no further action at this time. A **Federal Register** notice promulgating regulations or announcing a decision to take no immediate action is scheduled for November 1987.

EPA intends to make every effort to undertake the above activities within the timetable presented. However, the exact timing of many of the intermediate dates is contingent on outside parties or international agreements and therefore is subject to change. Any such changes will be discussed in individual Federal Register notices announcing the details of specific meetings and conferences.

Dated: November 29, 1985.

Charles L. Elkins,

Acting Assistant Administrator for Air and Radiation.

[FR Doc. 86–45 Filed 1–9–86; 8:45 am]

BILLING CODE 6560-50-M

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Part 68

[CC Docket No. 81-216; RM-2845; et al; CC Docket No. 84-490; RM-4458]

Connection of Telephone Equipment, Systems and Protective Apparatus to the Telephone Network; etc.

AGENCY: Federal Communications Commission.

ACTION: Notice of proposed rulemaking; correction.

SUMMARY: In a *Fourth Notice of Proposed Rulemaking* in CC Docket 81–216, the Commission solicited comments on whether any Part 68 terminal equipment interconnection limitations should be placed on computer-assisted automatic dialing equipment. The text of the Commission's decision printed in the **Federal Register** at 50 FR 51893 stated that comments would be due on February 1, 1986, and reply comments March 1, 1986. This correction establishes the date for comments as February 3, 1986, and for reply comments as March 3, 1986.

DATES: Comments are due February 3, 1986, and reply comments March 3, 1986.

ADDRESS: Federal Communications Commission, Washington, DC 20554.

FOR FURTHER INFORMATION CONTACT: Patrick Donovan, Common Carrier Bureau, Federal Communications Commission, Washington, DC 20554 (202) 634–1832.

SUPPLEMENTARY INFORMATION:

Erratum

In the matter of petitions seeking amendment of Part 68 of the Commission's rules concerning connection of telephone equipment, systems and Protective apparatus of the telephone network; notice of inquiry into Standards for Inclusion of one and two-line business and residential premises wiring and party line service in Part 68 of the Commission's rules; and petition to amend Part 68 of the Commission's rules to permit registration of terminal equipment for connection to voiceband private line channels that utilize loop start, ringdown or inband Signaling and Voiceband metallic private line channels, CC Docket No. 81–216, RM–2845, RM–2930, RM–3195, RM–3206, RM–3227, RM–3283, RM–3316, 3329, RM–3348, RM–3501, RM–3526, RM–3530; RM–4054. CC Docket No. 84–490, RM–4458.

Released: January 6, 1986.

1. In *Fourth Notice of Proposed Rulemaking*, CC Docket No. 81–216, FCC 85–591, released November 4, 1985, the Commission sought comment on whether Part 68 terminal equipment interconnection limitations should be

ENVIRONMENTAL DEFENSE FUND

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CHLOROFLUOROCARBON POLICY:

CHOICES
and
CONSEQUENCES

by

Daniel J. Dudek
ENVIRONMENTAL DEFENSE FUND

March 1987

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THE NEXT STAGE IN THE POLICY PROCESS

For the past year, the U.S. Environmental Protection Agency (EPA) has been conducting a series of public meetings and technical workshops designed to determine the need to further regulate chemicals which may threaten the stratospheric ozone layer. These fora provided the opportunity to disseminate the best information concerning the science, technology, and economics surrounding the use of chlorofluorocarbons (CFCs). The Agency is currently scheduled to promulgate its proposed regulatory decision this year.

The risk assessment phase of the domestic policy process is nearly complete. EPA's risk assessment document has been reviewed by its Science Advisory Board and will be published in final form shortly. For a summary of many of the effects identified in the assessment, see Dudek (1986). The next phase in the regulatory process is that of risk management, i.e. given the identified risks to human health and the environment, what are we going to do to manage those risks?

This paper addresses the range of regulatory choices available to EPA to manage ozone-depleting compounds and their emissions. The title of the report refers to chlorofluorocarbons (CFCs) only, but the actual range of chemicals under review is broader. EPA's regulatory focus is placed on the fully halogenated alkanes which include CFC-11, CFC-12, CFC-113, Halon 1211 and Halon 1301. These chemicals, due to their composition, pose the greatest threat to the ozone layer.

EPA is considering a variety of regulatory actions ranging from requirements to adopt specific emissions control technologies to economic-based incentives. Each policy choice differs in design, performance, cost, and impact upon industry. This paper describes the options and their differences. The paper begins by explaining the theory and operation of each policy and goes on to define criteria for evaluation. Each of the policy choices is then evaluated according to the criteria presented and its historical performance. Finally, implications of these choices for the environment and the economy are drawn in conclusion.

THE POLICY MENU

The diversity of industries employing ozone-depleting chemicals is extreme. Applications range from disposable party favors and dishware to commercial air conditioning and refrigeration. This diversity of applications means a diversity of emissions and possibilities for reduction and elimination. The environmental manager's problem is further complicated by the temporal distribution of emissions from uses. Some applications produce prompt emissions at the time of use, other uses place ozone-depleting chemicals in systems where some portion may be slowly emitted but their bulk remains stored until the system is disposed. Aerosols are a good example of the former while air conditioners exemplify the latter.

The difficulties involved in estimating emissions accurately are substantial. Frequently, data on industrial processes and their resulting emissions are not available. Rarer still is precise knowledge on the range of alternative technologies currently in use. The Rand Corporation is one source of information on alternative technological production processes and their emissions (Camm, et al., 1986). The Environmental Protection Agency (EPA) is continuing to conduct similar evaluations. The Alliance for Responsible CFC Policy is in the process of surveying member firms concerning their emissions reduction possibilities. Since the number of firms producing fully halogenated alkanes is small compared to the number of end-users, it is vastly easier (and cheaper) to estimate total production for any time period.

Given the difficulties associated with the estimation of emissions, an identity between production and emissions has been assumed by regulatory agencies. Some users have also indicated a preference for this assumption, despite the fact that their application actually involves banking CFCs for relatively long time periods. Thus, policies will focus on restricting production, directly or indirectly, in order to reduce emissions. Therefore, firms should be prepared to consider the consequences of restricted supplies. In effect, many of the environmental policies will be rationing schemes.

PRODUCTION LIMITS

The most direct way to limit emissions is to limit the quantities of ozone-depleting chemicals that can be produced. These limits can come in two forms. Persistent or fund pollutants, those whose slow or negligible decay rates result in accumulation in the environment, should have absolute limits for total production. Examples of these pollutants are lead, asbestos, fully halogenated chlorofluorocarbons, and the halons. Alternatively, fund pollutants may also be managed with a prescribed schedule of pre-programmed reductions over time termed a phase-down. Asbestos use is currently regulated according to a phase-down schedule. The U.S. negotiating position for the development of an international protocol for managing ozone-depleting chemicals embodies a phase-down with specified reduction levels but no dates. A similar proposal spanning a 5-year schedule has been introduced by Senator Chafee. Under most of the phase-down approaches, existing producers would be required to reduce production by specific percentages by specific dates. The phase-down approach is favored by most environmental groups.

Another variation in the stipulated production limit is a production capacity limit. CFCs 11 and 12 are currently regulated by the European Economic Community (EEC) with such a policy. In essence, member states have agreed that production capacity for these chemicals be frozen at existing 1980 levels. Actual annual production levels are allowed to fluctuate according to the dictates of the marketplace up to the maximum level implied by total productive capacity.

The Alliance for Responsible CFC Policy, a CFC industry coalition, has a policy position which would limit the rate of growth of production capacity. This is even a less restrictive approach than that taken by the European Economic Community. Presumably, under the Alliance's proposal, production would be allowed to increase at some maximum agreed rate. However, it is unclear how the additional increments in production would be allocated. Would new producers be allowed to enter the market? Depending upon the growth rate limit existing excess plant capacity could be exceeded at some future date.

COMMAND-AND-CONTROL

Most environmental regulation in the United States is of the "command-and-control" variety. Under this approach, polluters are required (the "command") to adopt pre-specified emissions abatement technologies (the "control"). Policies embodying specifications for reasonably available control technology (RACT), best management practices (BMP), and best available control technology (BACT) are no doubt very familiar to many of you. For example, BACT standards could be developed which would require carbon absorption to be used to capture CFC emissions from flexible foam-blowing. Increasing the size of recovery tanks on retail food refrigeration units is another example.

There are numerous variations on this basic theme. One common policy which is often embodied in the command-and-control type of regulation is the emission limit. Emission limits specify a maximum allowable discharge per unit time, or per unit output, or a maximum ambient concentration averaged over specified time intervals. Conceivably, EPA could set maximum emission limits for the use of CFC-113 in different solvent applications.

The most extreme form of command-and-control regulation is the use ban. EPA, in 1978, acted to ban the use of CFCs as an aerosol propellant in non-essential uses. Although this is a potential regulatory option available to EPA, it has not been the focus of active discussion. Individual state agencies and legislatures, however, are interested in such an option. Targets for such legislation include various packaging and food service products which have been produced with CFCs as a blowing agent.

EMISSION FEES OR PRODUCT TAXES

Emission fees have long been advocated by economists as a tool for controlling emissions. Fees are one of a class of economic, incentive-based policies which rely on the importance of price as a signal to decision makers within firms. The size of the price change is the strength of the signal and the strength of the incentive to conserve the regulated chemicals and search for alternative processes or chemicals. Given the difficulty and cost of measuring emissions from individual applications, fees are most likely to be levied against production. Under such arrangements, producers would pay the tax to the government and pass it on to industrial consumers of ozone-depleting chemicals. This is effectively a use tax for those applications without the possibility of recycling. Virgin production would be taxed, but CFCs reclaimed and reused would not be subject to the tax.

Three types of fees have been discussed for potential application; a flat fee, a contingent fee, and an escalating fee. The flat fee would be set at a once-and-for-all level which would be designed to bridge the expected cost differential between current CFC formulations and non-depleting alternates. By closing that gap, the policy would accelerate investment in the production of alternates by enhancing their competitiveness with currently less costly, but damaging CFCs. The flat fee would not impose any limit on the availability of fully halogenated CFCs, but would rely on the functioning of market processes to control their production and use. Such a fee has been proposed legislatively by Senator Baucus.

The contingent fee is a proposal which is designed to allow EPA to coordinate domestic regulatory performance with the requirements of any international agreement. For example, suppose an international agreement took the shape of the current U.S. proposal. Such an agreement would require the U.S. to attain fixed reductions in production according to an agreed timetable. The contingent fee policy would allow EPA to vary the size of the fee as needed to achieve these reductions. This approach could also be used to implement a domestic phase-down policy.

A close relative of each of the preceding proposals is the escalating fee. This policy would publish a pre-determined fee which would continue to increase in strength over time. By steadily increasing the fee over time, users are given an unequivocal signal that continued use of the regulated chemicals will become increasingly expensive. This pre-announced schedule of increases is designed to facilitate strategic planning and add further impetus to the elicitation of alternatives. In addition, any countervailing forces such as inflation, which would tend to diminish the force of the flat fee would be negated. At the same time, however, an escalating fee could promote stockpiling to avoid future taxes. Storage of CFCs would be stimulated if storage costs were less than avoided taxes.

MARKETABLE PERMITS

A newly promoted policy approach is marketable permits. Permits defining allowable behavior or performance are very common. For example, permits have been widely used in the management of water quality under NPDES. Most permits, however, are not transferrable between potential users. Notable exceptions are liquor licenses, New York city taxi cab medallions, and airport landing slots. The marketable permit policy would involve the creation of permits for either production or use of CFCs. These permits could be annual, multi-year, or once-and-for-all. The key feature of this approach is the marketability of the permits. Marketable production permits (MPPs) would entitle the holder to produce the amount of CFCs allowed by the permit or to sell (or lease if multi-year) the entitlement to another producer. Marketable use permits (MUPs) would allow the bearer the right to use the quantity of CFCs denominated by the permit or to sell the permitted quantity to another user. In either case, production or use, the holders of permits would evaluate the revenues received from use of the permitted quantity versus the revenues derived from sale of the permit. This potential for free transfer of the regulated commodity is designed to promote economic efficiency and remove the market distortions that can be caused by restricting freedom of choice and action for firms. Permits could be distributed by executive fiat according to some base production or use or auctioned.

A close analog to the proposed use of marketable permits for CFCs is the emissions trading program implemented under the Clean Air Act. In this program, emissions reduction credits (ERCs) are earned by firms for attaining greater than mandated emissions reductions. ERCs can be sold to firms within the same airshed for whom compliance through the installation of control technology would be more expensive than the purchase of credits. In this fashion, firms that have a comparative advantage in reducing emissions are given an incentive to do so.

The primary thrust of emissions trading is the improvement of the efficiency of attaining given environmental objectives. Most recently, a variation on this theme was introduced for the exchange of "lead rights" between gasoline refiners to aid compliance with EPA's lead phase-down. Again, this program was designed to reduce the costs of this program by allowing trading in lead additive amounts between refiners of differing efficiencies under pre-specified averaging rules.

Marketable permits operate directly on the quantity of a commodity by regulating its availability. Market response to this supply constraint is then reflected in increased prices as users bid for command over supplies. This is the real leverage that permits exert since the new price signals will influence all use decisions. As such, they take advantage of the mirror relation between quantity and price in a market economy.

To be most effective marketable permits should be sold by the EPA in an open auction. Anyone, producers or users or distributors, would be eligible to bid. Users and distributors would participate in the auction in order to guarantee CFC supplies at a reasonable price. Successful bidders would then ask producers to bid on supply contracts and pick the most attractive offer. Producers would also be interested in bidding for permits since they could market CFCs with the permit cost bundled in for a premium.

CHOOSING A POLICY

Policy choice in the United States is a unique amalgam of interactions between interested parties, responsible authorities, economics, and politics. Today's conference is one element in that alchemy. In the process of policy determination, each of the actors brings a perspective which is a view from a particular constituency's vantage. As a result, each participant may have a different set of criteria and weights by which the desirability of a policy option is assessed. The criteria discussed in this paper are not exhaustive, rather they attempt to capture the main concerns of those affected by this regulatory process.

CRITERIA FOR CHOICE

- Effectiveness
- Cost
- Flexibility
- Equity

CRITERIA FOR CHOICE

Effectiveness in Solving the Problem

Of most immediate concern is whether the particular policy is capable of solving the environmental problem to which it is addressed. Can it do the job? Before that question can be answered, we must know a bit more about the job, i.e. the policy objective. The following passage from Lewis Carroll in which Alice questions the Cheshire Cat illustrates this imperative nicely.

> "Would you tell me, please, which way I ought to go from here?
> "That depends a good deal on where you want to get to," said the Cat.
> "I don't much care where --" said Alice.
> "Then it doesn't matter which way you go," said the Cat.
> (Alice's Adventures in Wonderland, p. 88)

As we have learned in this policy process, science cannot tell us where to go. That decision will be made on other grounds. But once that decision is made, science can help us get there most efficiently.

The policy goal is the protection of stratospheric ozone from depletion. Atmospheric scientists are unable to prescribe a safe level of emissions of ozone-depleting chemicals. Nor are they able to tell us what is an "allowable" level of depletion. The latter is an ethical question for which scientists have no particular comparative advantage. Therefore, mindful of the extensive consequences of ozone depletion, the long-run solution to the problem of depletion is to stimulate the development and adoption of non-depleting alternatives. Along the way down this path, we should reduce emissions and encourage recycling and reuse. Effectiveness is consequently guaged in terms of emissions reduction potential and impetus to substitute non-depleting alternatives.

Not all instruments can be expected to perform equally well in guaranteeing that emissions will be reduced. Policies with little latitude for individual firm discretion, such as requirements to employ best available technology (BAT), would receive high marks in this category. Policies for which there is little or no regulatory experience, such as emission fees, would be expected to receive relatively low marks despite their inherent potential.

The existing regulatory track record is only one piece of available data. The effectiveness of a particular regulatory tool depends upon its design, implementation, and the dynamic response of users. For example, the adoption of BAT regulations will result in a given emissions reduction. In this case, the reduction achieved is largely a function of the inherent limits of the prescribed technology and its operation. Reductions are certain, if the technology is operated within its tolerances. However, equally certain is the lack of incentive for firms to develop new technologies for emissions reduction. BAT becomes the most that anyone will accomplish unless entirely new production processes are developed which happen to have other cost advantages.

Incentive-based policies, such as fees and marketable permits, overcome this limitation by providing entrepreneurial individuals and firms with the possibility of using regulatory action to create new opportunities. Porter has noted that "The rules of the game cannot achieve their intended effect unless they anticipate correctly how businesses respond strategically to competitive threats and opportunities" (p. x). From this vantage, regulation can act to create new markets or to add barriers within existing markets. The former case is exemplified by markets for emissions reductions, whereas the latter is frequently cited to be the case with BAT. The impetus for innovation is given by the incentive incorporated within the policy. For example, if a fee (or tax) per unit of emission is levied, the firm has the choice of discharging and paying the fee or abating emissions and avoiding the fee. The choice of discharge versus abatement will depend upon their relative costs. As long as abatement is cheaper than discharge, profit seeking firms will reduce emissions. The exact level of reduction for each firm is determined by equating the cost of the next unit of reduction and the fee. At this point, the firm is indifferent between incurring the added cleanup cost or paying the fee.

Under this regulatory scenario, it would pay firms to develop low cost technologies to reduce emissions. The licensing of a patented emission reduction technology could be a lucrative side line for a firm responding creatively to a regulatory environment. This message is encapsulated in 3M's Pollution Prevention Pays program. Employees are encouraged to submit suggestions for pollution reduction and are rewarded with a share of the cost savings that result. Incentive-based policies harness the creative energies of firms, managers, and employees in the pursuit of better cost-effective solutions to environmental problems. This stimulus to innovation offers the promise of reducing the total quantity of resources devoted to solving a particular environmental problem, releasing them for productive use elsewhere in the economy.

Enforcability

The ease of monitoring compliance with the regulatory objective is also an important determinant of the effectiveness of any policy instrument. If it is either impossible or very costly for EPA to determine compliance, then enforcability is weak and the effectiveness of any policy is less certain. In general, the more detailed the regulation in prescribing firm operations, the more difficult the monitoring problem. Command-and-control policies specifying emission limits for individual operations would also present monitoring challenges. To the extent that users are rational polluters, enforcability is an important element in the private decision calculus concerning the degree of compliance.

Cost

The cost of a policy is an important performance criteria in society's problem of choosing among alternative tools. The lower the cost of attaining a particular environmental objective, the greater the general level of economic welfare since fewer resources are devoted to solving the problem. Appropriate costs include resource costs, transfer payments, administrative costs, and safety costs. Resource costs are explicit outlays incurred in the process of adjusting to the regulation. Examples of such outlays include expenditures on redesigning production facilities or purchasing more expensive substitutes. Transfer payments measure the size of any increased costs for CFCs. For example, production limits could reduce available supplies, increase competition, and drive up prices.

Administrative costs, the actual costs of putting the policy on the ground and running it, will vary with the ease of administration, implementation, monitoring, and enforcement. Consider only one element of EPA's decision problem, say the information costs associated with defining the policy level. Traditionally, information costs have been high for command-and-control approaches because the precise control levels have been determined through detailed engineering studies.

Flexibility

For the management of this particular environmental problem, flexibility is a potentially important attribute of a policy. Our understanding of the problem of stratospheric ozone depletion and its consequences have changed dramatically in the past few years. These changes in our perception of the problem have been driven as much by advances in atmospheric science as revelations of changes in the environment. However, we have been continually apprised of gaps in our models and theories and their ability to explain phenomena like the massive seasonal depletions in ozone over the Antarctic continent.

The possibility that the Antarctic "hole" is the harbinger of some more generic depletion phenomena that would play itself out all over the globe is one reason to value flexibility. If the statistical analysis of satellite observations which show existing depletions several times greater in magnitude than those predicted by models are verified by NASA, then this would be cause for an increased pace of regulatory effort. This is another reason to value flexibility. The ability to adjust the level of policy effort relatively quickly is an important element in accommodating the surprises that the environment and science may bring.

Equity

The critical equity concerns are the differential impacts of alternative policies between firms, industries, and sizes of firms. Basically, we are interested in assessing who benefits and who pays. These distributive issues are highlighted in the consideration of transfer payments. For example, suppose that production limits are implemented with marketable production permits. If such permits were simply distributed to reflect the existing pattern of ownership of production facilities, then the current producers of CFCs would receive the transfer payments. On the other hand, the government could choose to auction off the permits in which case transfer payments would be distributed between the government and permit purchasers in proportions which depend upon the outcome of the auction. To the extent that the government receives these revenues, social costs are reduced. Theoretically, these revenues could be used to fund compensatory programs involving low interest loans for process conversions or direct subsidies for the purchase of non-depleting alternatives.