Collection: Masterman, Vicki: Files
Folder Title: Stratospheric Ozone III (3 of 7)
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U.S. NEGOTIATING STRATEGY
UNEP OZONE PROTOCOL NEGOTIATIONS
THIRD SESSION: APRIL 27 - 30, GENEVA

PROTOCOL ELEMENT	U.S. POSITION
1. <u>Chemical coverage</u> ① all shld be incl'd in one form or another ② can explore flexible approaches for ea compound	A. Include CFC 11, 12, 113, 114, 115, and Halons 1211 and 1301 B. Flexible treatment of 114, 115, and Halons European produc.
2. <u>Calculation of Emissions</u> Be careful to preserve alt def's of D (i.e. wrt permanent encapsulation)	A. Support "Adjusted Production" formula (P+I-E-D) B. Consider other viable "hybrid" formulas C. Introduce Mkt approach
3. <u>Stringency</u> freeze ① yr.	
First Step: 20% ② yrs	A. Freeze emissions at 1986 levels
Interim Step: (EC proposes 20% reduction via automatic trigger)	A. 50% reduction via automatic trigger B. 20 - 40% reduction via automatic trigger
Final Phase: leave open for future (avoid detailed discussion; focus on interim step)	A. per Circular 175
4. <u>Timing</u>	
Freeze: (EC proposes 2 years after entry into force)	A. 1 year after entry into force
Interim step: (EC proposes 6 years after entry into force)	A. 4 - 10 years after entry into force (depending on stringency)
Final phase:	A. 10 - 15 years after entry into force (per Feb. 1987 USG position paper)

PROTOCOL ELEMENTS	U.S.POSITION
5. Country Coverage	A. Seek widest possible participation — include all major producing countries (seek entry into force provision which assures this) — encourage LDCs to join (see #6 and 7 below)
6. Trade Aspects (strong, workable non-Party import restrictions supported by all delegations)	A. Support draft Trade article — Ban bulk imports from non-parties — Ban/restrict non-party imports of products containing — Determine feasibility of restricting non-party imports of products made with (resist attempts to amend this to a restriction) — Seek drafting improvements recommended by inter-agency trade group
7. Developing Countries	A. Develop provisions to ensure broad LDC participation with minimal loss of environmental protection — Possible exemption from control measures — Resist attempts for mandatory technology transfer provisions
8. Scientific Assessment (all delegations support as integral part of protocol)	A. Develop assessment and review article (based on U.S. text) — regular review: every 4 years (EC supports) — emergency review: as determined by Parties

Ozone Interagency Meeting - April 17, 1987

Talking Points

-- Stress importance of ozone negotiations to U.S. foreign policy, and support for U.S. position by Secretary Shultz, Deputy Secretary Whitehead, and Under Secretary Wallis.

-- U.S. has had acknowledged leadership role in recent months on this issue -- with EC, Nordics, Canada, Japan, LDC's.

-- We have come a long way in the negotiations, and are on the verge of successful and reasonable international agreement which would be a credit to the Administration.

-- Intense interest from public interest groups and Congress; first question asked of me at a public symposium yesterday was whether U.S. is backsliding from our ozone position.

-- There is great concern at Department of State that the basic U.S. position is being questioned in certain quarters.

-- It is unacceptable for us to switch to a passive mode at the next round, and to refuse to address the central issue of the negotiation: stringency and timing of CFC reductions.

-- It would be a political embarrassment to the Administration, and it would have undesirable repercussions in our relations with key partners in the EC and elsewhere.

-- Moreover, if we are now perceived as obstructing the international agreement, it would lead to domestic court and legislative action for unilateral and extreme U.S. controls which would both disadvantage U.S. industry and not adequately protect the ozone layer.

-- The U.S. delegation leaves in a week for these negotiations, and I understand there is still no position paper. I would like to know agency views now on the matter of negotiating at Geneva on stringency and timing of CFC reductions.

4/17 1:00pm

POINTS OF AGREEMENT

The Stratospheric Ozone Problem

1. A USG goal is to prevent harmful depletion of stratospheric ozone.

   A. Atmospheric concentrations of certain ozone-depleting chlorofluorocarbons and halons are increasing.

   B. If the stratospheric ozone layer is significantly depleted, significant adverse health, crop, and environmental effects are likely.

   C. Despite the remaining uncertainties, the scientific findings to date have prompted strong domestic and international pressure for action to reduce emissions of ozone-depleting chemicals.

2. The USG prefers international action over unilateral domestic action for economic and environmental reasons.

   A. Insuring the progress of the international negotiations toward an agreement is important.

   B. The international agreement must include as many countries as possible.

   C. The international agreement should cover the five main ozone-depleting chemicals (CFC 11, CFC 12, CFC 113, Halon 1201, Halon 1311).

   D. Parties to the agreement should share equitably in the costs.

      (1) The Departments of Interior and Commerce recommend that an international agreement give the USG due credit for past unilateral reduction of aerosol emissions.

      (2) EPA and the State Department question whether the USG is due credit for such past unilateral reduction and note that past attempts to obtain such credit have failed.

   E. The international agreement must contain an enforceable trade provision to encourage compliance by parties and to encourage non-parties to join.

   F. The international agreement must provide for periodic scientific assessments to verify or change the scope of the agreement as to reduction targets, reduction schedules, chemical coverage, compliance and trade.

Actions to Date

1. The USG has participated in two international negotiating sessions toward a Protocol to the Vienna Convention on the control of ozone-depleting chemicals. The next negotiation is scheduled for April 27-30.

   A. The State Department received authority to negotiate a protocol pursuant to interagency approval of the Circular 175 authorizing the USG delegation to negotiate a protocol for:

   > "I. A near-term freeze on the combined emissions of the most ozone-depleting substances;
   >
   > II. A long-term scheduled reduction of emissions of these chemicals down to the point of eliminating emissions from all but limited uses for which no substitutes are commercially available (such reduction could be as much as 95 %), subject to III; and
   >
   > III. Periodic review of the protocol provisions based upon regular assessment of the science. The review could remove or add chemicals, or change the schedule or the emission reduction target."

   B. The Executive Branch is currently considering options within the terms of the Circular 175 including the definition of a freeze, the delineation of near-term and long-term and the specification of a percentage reduction.

2. The USG delegation is currently developing the USG position for the April 27-30 negotiations.

   A. The USG negotiating position in the past two meetings has been for a near-term freeze and a 95 percent reduction in an unspecified time period.

   B. The State Department and EPA believe the future progress of the negotiations depends upon USG adjustment of its position to reflect the developments of past sessions.

   C. The Interior Department, the Commerce Department and OMB resist finalizing the USG position prior to DPC consideration, yet do not wish to jeopardize the continuation of the international negotiations.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md. 20852

R/PDC

August 27, 1987

Dear Colleague:

Enclosed is the document entitled: "Stratospheric Ozone: The State of the Science and NOAA's Current and Future Research" for your use. The principal author was Dr. Daniel Albritton, Director, Aeronomy Laboratory, who worked with other NOAA colleagues. If you perceive a use for this document, please call my office (443-8721) for additional copies.

Sincerely,

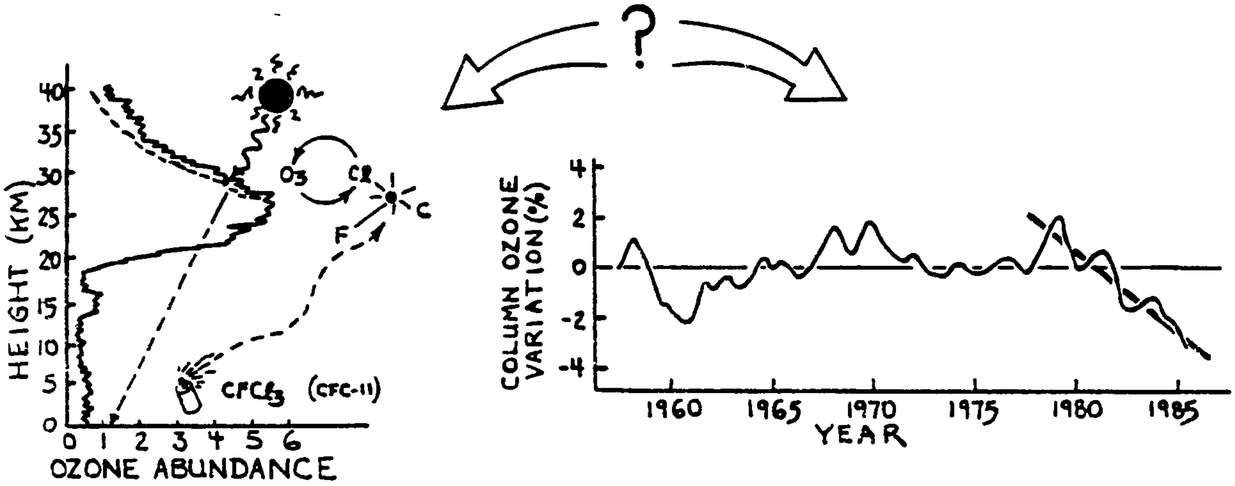
Chandrakant Bhumralkar
Director, Program Development
and Coordination Office

Enclosure

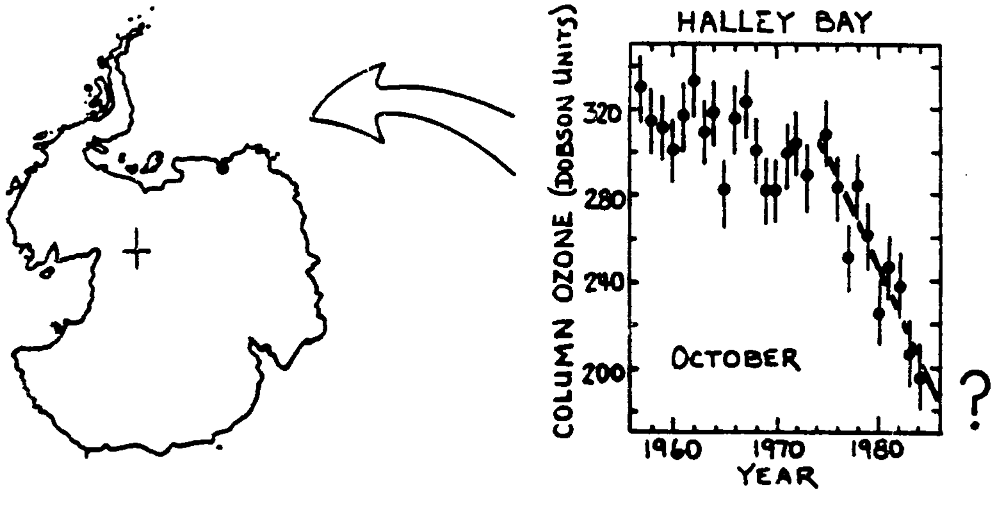
STRATOSPHERIC OZONE:

THE STATE OF THE SCIENCE
AND
NOAA'S CURRENT AND FUTURE RESEARCH
July 1987

• Global



• Antarctica



COVER

- GLOBAL OZONE

Emissions of man-made chlorine-containing chemicals are predicted to be depleting the earth's stratospheric ozone layer, which shields life on the surface from harmful solar ultraviolet radiation. This theory predicts that losses in the global-average overhead column of ozone are less than a percent at present, but would grow to several percent in the next century if emissions were to continue their current growth rates.

The 25-year monitoring record of global ozone shows that column ozone increased a few percent in the 1960's, remained relatively invariant through the 1970's, and decreased afterwards. Attention has focused on the recent decrease because it has occurred during the period of increasing stratospheric chlorine abundance. However, the powerful El Chichon volcanic eruption and the unusually strong 1982-83 El Nino also occurred during this period. Both could have influenced stratospheric ozone.

Is the recent global ozone decrease due to man-made chlorine chemistry, natural influences, or both?

- ANTARCTIC OZONE

Observations have discovered growing ozone decreases over Antarctica in the austral spring season that have now reached 40 to 50%. Such decreases are the largest ozone changes ever observed. This trend was totally unanticipated.

Several theories have been proposed to explain this unusual phenomenon: man-made chlorine chemistry, sunspot-induced chemistry, and climatologically changed ozone circulation patterns. Recent measurements have shown that both the chemical and meteorological parameters in Antarctica have changed.

Is this "ozone hole" the first indication of human-induced ozone destruction, a newly discovered natural phenomenon, or both?

STRATOSPHERIC OZONE:

THE STATE OF THE SCIENCE
AND
NOAA'S CURRENT AND FUTURE RESEARCH

31 July 1987

CONTENTS

CONTENTS (Continued)

SUMMARY

Atmospheric ozone is central to the chemistry, climate, and habitability of the planet. Hence, NOAA has committed a substantial effort to observing, understanding, and predicting ozone's atmospheric roles and effects as they relate to current environmental issues. The status of the science of stratospheric ozone and NOAA's research can be summarized briefly as follows.

GLOBAL STRATOSPHERIC OZONE DEPLETION

Background:

- According to a hypothesis proposed in 1974, man-made halogen-containing chemicals [including chlorofluorocarbons (CFC's), which contain chlorine, and Halons, which contain bromine] may be depleting stratospheric ozone globally.
- The ozone layer, which lies between 10 and 50 km, shields the earth's surface from harmful solar ultraviolet radiation and establishes the temperature structure (hence circulation patterns) of the stratosphere.
- Man-made emission rates of chlorine have greatly exceeded those of natural emissions.
- While the restrictions in the 1970's on the use of CFC's in aerosol sprays halted the rapidly increasing emission rates of the preceding decade, global emissions have begun increasing again in recent years.
- National policy discussions are focusing on the need for further emission regulations on the halogenated compounds, and international negotiations are also underway in that regard.

Theory:

- From a scientific perspective, any proposed regulatory policy should consider all of the fully halogenated compounds, which are characterized by high ozone depleting potentials and long atmospheric lifetimes, as a group for the purposes of regulation.
- Several chemical compounds that have low ozone depleting potentials may have significant value as possible future substitutes.
- The current understanding of stratospheric chemistry and circulation predicts that the halogenated compounds will alter the
    - total column amount of ozone overhead,
    - variation of this column ozone with latitude, and
    - vertical distribution of ozone.

- The fully halogenated compounds have long atmospheric lifetimes; therefore, their stratospheric abundance would continue to grow for many decades, even if their emissions were to plateau or decrease moderately.

- Hence, from the standpoint of limiting the maximum concentrations of chlorine and bromine in the stratosphere, emission-rate restrictions done earlier need not be as severe as those done much later.

- The response of stratospheric ozone to emissions of halogenated compounds is sensitive to the atmospheric growth rates of other trace gases, such as carbon dioxide, methane, and nitrous oxide, which are emitted from man-made and natural sources.

Predictions:

- Policy has not set a "tolerable" stratospheric ozone loss. Therefore, as an aid to judging the significance of a possible ozone loss, each of the following predictions are compared to observed natural variability.

Global-average column ozone

- Model predictions for all scenarios that include continued growth of the emissions of the halogenated compounds at current rates or greater show global-average column ozone losses in the next century that are larger than or equal to observed natural ozone decadal variability, which is about 3 to 4%.

- Hence, a true global freeze of the sum of the chlorine and bromine reaching the stratosphere to current rates is consistent with limiting predicted long-term perturbations in the global-average column ozone to magnitudes less than the decadal natural variation.

- This prediction (as well as the ones below) assumes continual current percentage growth in carbon dioxide and methane. If less growth actually occurs, then more column ozone depletion is predicted; if more growth occurs, less column ozone depletion is predicted.

High-latitude column ozone

- The current understanding of the interaction of stratospheric circulation patterns and ozone-loss chemistry predicts that more column ozone loss will occur at higher latitudes than at the equator.

- Hence, a significant decrease in total chlorine and bromine emission rates is consistent with limiting predicted long-term perturbations in the column ozone at high latitudes to magnitudes less than decadal natural variation.

Upper-stratospheric ozone

- Even with a global freeze, current theory predicts substantial long-term losses of ozone at 40 km, which may alter stratospheric circulation patterns because of the accompanying cooling.

- Hence, a <u>significant decrease</u> in total chlorine and bromine emission rates is consistent with limiting predicted long-term losses in the ozone at 40 km and associated decreases in local temperatures to magnitudes less than the current (limited) observations of decadal natural variation, which is about 1 to 2°C.

- However, the couplings and feedbacks of chemistry, radiation, and circulation in the upper stratosphere have yet to be represented fully in three-dimensional models. Furthermore, the possible effects of the predicted upper-stratospheric cooling on life at the earth's surface are unknown at present.

Greenhouse effect

- In addition to their relation to stratospheric ozone, many of the halogenated compounds absorb infrared radiation and hence contribute to the "greenhouse" effect, which elevates surface temperatures.

- A <u>decrease</u> in the total emission rates of halogenated compounds appears to be consistent with limiting their predicted commitment to a long-term "greenhouse" warming such that it is less than the decadal natural variation, which is about 0.5°C.

<u>Uncertainties</u>:

- All of the above ozone responses are predictions made by atmospheric models that are based on the current understanding of the relevant atmospheric processes.

- While these models indeed simulate much of the present atmosphere very well, they are not perfect, which places a factor of two to three uncertainty on their predictive abilities.

- Since stratospheric ozone is sensitive to changes in other trace gases, an additional uncertainty is the difficulty in predicting their future abundances, particularly those of carbon dioxide and methane.

  Nevertheless, most atmospheric scientists believe that if the present growth rates of chlorinated and brominated compounds continue unabated indefinitely, then it is highly likely that substantial global ozone depletions will occur in the next century, particularly at the higher altitudes and latitudes.

Ozone Trends and Interpretations:

- The ground-based "Dobson" spectrophotometer network provides a 25-year record of global-average column ozone, which increased a few percent in the 1960's, remained relatively invariant in the 1970's, and decreased afterwards. Attention has focused on this recent 4-5% decrease because (a) it is the most-rapid sustained change ever observed in global column ozone and (b) it has occurred during the period of increasing stratospheric chlorine abundances.

- The causes of the decrease are not yet known. Solar variability, volcanic aerosols, and general circulation changes are possible contributing natural mechanisms. Indeed, analyses of solar activity find no fully convincing statistical evidence of a human-caused depletion in global column ozone in recent years, which is consistent with theoretical predictions that current losses should be less than a percent.

- The "Umkehr" technique, which uses the Dobson instruments, yields an 18-year record of the vertical distribution of ozone. Over the past decade, the data show ozone decreases at the higher altitudes (and only there) that are remarkably close to model-predicted depletions. However, questions about artifacts due to volcanic dust, particularly since the 1982 eruption of El Chichon, prevent a definitive statement regarding the significance of the trend.

- Unpublished results from the NASA SBUV-1 instrument on the NIMBUS 7 research satellite apparently show distinct ozone decreases over the past eight years, both in the global column and in the upper-stratospheric abundances, that are substantially larger than those of the Dobson and Umkehr data or the theoretical predictions. However, this analysis and the calibrations are undergoing intensive review, and the results are not yet accepted by the scientific community.

- Inconsistencies between parts of the data sets and the possibility of instrumental artifacts have divided the atmospheric science community, and there is presently no universal agreement on whether there is evidence of a chlorine-induced depletion in global ozone.

Future NOAA Research:

- NOAA will continue to focus on reducing the uncertainties in the theoretical predictions of stratospheric ozone perturbations. Specifically, the near-term efforts will be to:
    - measure, in collaboration with NASA, the abundance of stratospheric reactive nitrogen, which is an important parameter in ozone chemistry,
    - monitor the atmospheric concentrations of the fast-growing new chlorinated and brominated compounds,
    - construct theoretical models that accurately simulate the three-dimensional transport and chemistry of ozone,

  - develop an improved theoretical treatment of radiative transfer in the atmosphere and test it against vertical-distribution radiation measurements, and
  - develop improved model capability for evaluating the climatic responses to atmospheric ozone changes.

- NOAA will continue to focus on improving the monitoring record. Specifically, it will:
  - continue participation in the Dobson and Umkehr networks and improvement and assessment of these methods,
  - collaborate in a reassessment of the entire ozone data set, examine the significance of trends and the meaning of the inconsistences, and plan to report the results by the end of 1987,
  - continue to collaborate in the analysis of the trends in ozone, temperature, and other data and in the assessment of the agreement between observations and theory,
  - continue the recently begun series of measurements with the SBUV-2 instrument on the TIROS satellite series and plan to implement an improved measurement system on future satellite series, and
  - participate in the planning of a state-of-the-art ground-based remote-sensing network that will detect stratospheric change, serve as a test of stratospheric theories, and provide a complementary absolute calibration, backup, and extension of the satellite monitoring systems.

ANTARCTIC STRATOSPHERIC OZONE DEPLETION

Background

- Dobson, satellite, and balloon-borne instruments have revealed growing, major (50%) ozone decreases over Antarctica in the austral spring season. The existence of this "ozone hole" is established beyond doubt.

- Halogen-chemical, sunspot-induced chemical, and dynamical/climate-change theories have been postulated. The first evokes man-made perturbations; the latter two evoke natural processes.

- The paucity of chemical and physical data at the time that these theories were proposed prevented assessment of their correctness.

1986 Ground-based Expedition

- Last summer, NSF, NASA, NOAA, and the CMA supported a 20-investigator expedition to McMurdo Base, Antarctic, led by a NOAA scientist, to provide additional data on the "ozone hole".

- The balloon-borne and ground-based ozone results show a 40% loss, mostly in the lower stratosphere, which makes the sunspot-induced chemical theory a less-likely explanation.

- Other measurements, also made by two different techniques, reveal that the abundance of the reactive chlorine compounds is highly elevated compared to other regions of the globe. Remaining uncertainties, however, prevent unequivocal identification of the man-made halogenated compounds as the cause of the ozone loss.

- Until the cause is established, the question as to the implication of the Antarctic decreases for global ozone cannot be answered.

- Because the current theories of the "ozone hole" require the unique physical features of Antarctica, the failure of the "standard" global ozone-depletion theories to predict its occurrence does not necessarily imply that these theories have major shortcomings regarding their predictions in other regions.

Plans for the 1987 Ground-based and Airborne Expeditions

- It is now established that chlorine chemistry and meteorological features are both enhanced in the Antarctic stratosphere, compatible with chemical and dynamical theories, respectively. Thus, it is mandatory to understand their respective roles in the "ozone hole" in much more detail. Consequently, NOAA and other agencies plan a greatly expanded effort during 1987.

- First, NOAA scientists will take an improved instrument back to NSF's McMurdo Base and will also provide year-round ozonesonde balloon launches from the South Pole during 1987. Scientists from other agencies and institutions will make up an expanded ground-based research effort this summer.

- In addition, NOAA will join NASA, NSF, CMA, and university investigators in an aircraft expedition to probe the stratosphere at the altitudes where the ozone decrease is occurring. The flights will be based out of Punta Arenas, Chile.

- NOAA scientists will have five chemical instruments on board NASA's ER-2 and DC-8 aircraft, and one of these investigators will serve as mission scientist. The full instrument payload will address very many of the key chemical constituents and physical parameters that are needed for testing the current chemical and dynamical theories.

- NOAA will help provide satellite ozone data that will locate the "ozone hole" and define its shape for the flight planning.

ASSESSMENTS AND SCIENTIFIC INPUT TO POLICY

- Scientific discoveries continue to be made (e.g., the "ozone hole") and understanding improves (e.g., the forthcoming trends re-evaluation). Hence, regular assessment of the state of knowledge is a key part of policy refinement. NOAA will continue to contribute to such reviews and assessments.

- In addition, NOAA will continue its participation in the current international negotiations of a CFC/Halon protocol and will strive to help provide the scientific advice needed to base these negotiations on the most-complete current understanding of atmospheric circulation and chemistry.

STRATOSPHERIC OZONE:

THE STATE OF THE SCIENCE
AND
NOAA'S CURRENT AND FUTURE RESEARCH

I. INTRODUCTION

A. RATIONALE

The National Oceanic and Atmospheric Administration (NOAA) is focusing a substantial fraction of its environmental research on atmospheric ozone (O_3). The justification can be stated simply: ozone is the single most important chemically active trace gas in the earth's atmosphere. The reasons for this strong assertion are manyfold. The two that are the most relevant to this stratospheric-ozone summary are:

- The stratospheric ozone layer (between 10 to 50 km) is an ultraviolet shield that is essential to life on the planet.

- The temperature structure and hence the circulation patterns of the stratosphere depend on the distribution of ozone in this region.

B. ENVIRONMENTAL ISSUES

Around these key atmospheric roles of stratospheric ozone revolve two current environmental issues and their associated scientific questions:

(1) Releases of man-made chlorine- and bromine-containing compounds into the atmosphere are predicted to be depleting the stratospheric ozone layer.

   - How scientifically sound is this hypothesis?

   - What are the future ozone depletions predicted for continued emissions of these compounds?

   - If these depletions were to occur, what would be the atmospheric and climatic consequences?

   - Is there any unequivocal observational evidence that stratospheric ozone is indeed being perturbed at present on a global scale by human activities?

(2) Very recently, it was discovered that substantial year-to-year ozone decreases are occurring in the Antarctic stratosphere during late austral winter and early spring.

   - What is the cause of this "ozone hole", i.e., natural or man-made?

- What are the implications for <u>global</u> ozone?

These are challenging scientific and environmental questions to which policy makers rightly demand the best up-to-date, objective, scientific analyses that accurately reflect both the knowns and the unknowns of the situation. This summary describes (a) NOAA's current contributions to providing answers to these questions, (b) the future research plans in that regard, and (c) the current state of the science as it relates to public policy.

II. GLOBAL STRATOSPHERIC OZONE DEPLETION

A. THE PROBLEM

In 1974, two chemists at the University of California at Irvine hypothesized that man-made chlorofluorocarbons (CFC's) may be depleting the stratospheric ozone layer. Figure 1 schematically shows this hypothesis superimposed on a typical observed vertical-distribution profile of ozone in the atmosphere. The main features of the ozone-depletion hypothesis are noted and are as follows:

(1) CFC's are being emitted at the earth's surface in what generally have been increasing quantities.

(2) The only significant loss of these compounds is a slow (relative to the past emission rates) photodissociation in the stratosphere, the result of which has been a long-term buildup of stratospheric chlorine.

(3) The chlorine fragments catalytically destroy many ozone molecules, i.e., the chlorine atom is not consumed in the total process.

(4) A thinner ozone layer would absorb less solar ultraviolet light, resulting in a cooling of the upper stratosphere.

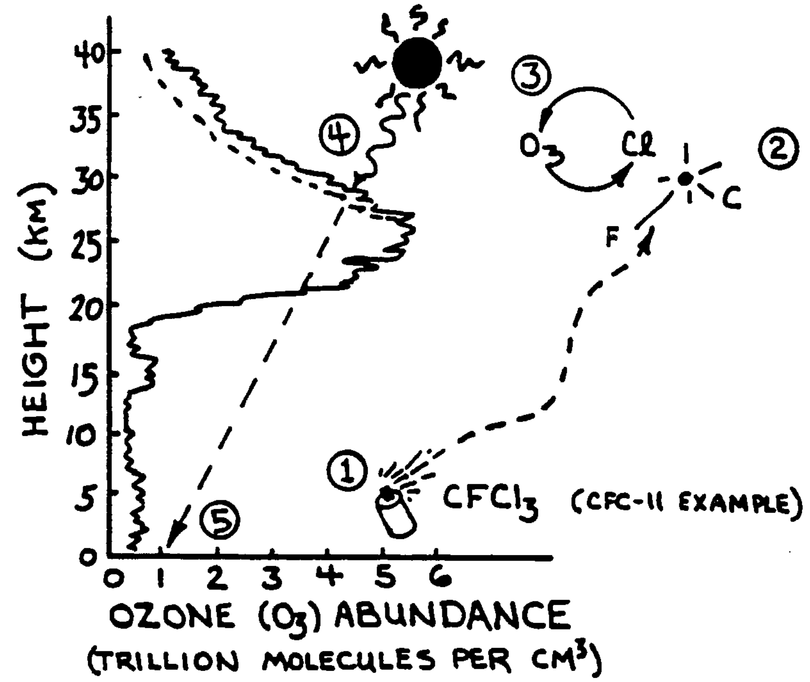


Figure 1. A schematic representation of the elements of the ozone-depletion hypothesis (Molina and Rowland, 1974). (Solid curve: ozone profile at 41°N, 106°W on 11 February, 1983. NOAA ultraviolet photometer data.)

(5) The increased ultraviolet radiation at the surface would cause elevated incidences of skin cancer, cataracts, and other biological effects, including disruption of some terrestrial and aquatic ecosystems.

The first four elements of this hypothesis relate to atmospheric responses. The last element relates to biological responses, which, while a crucially important part of the hypothesis, are outside the scope of this summary document and of NOAA research.

Over the decade since this hypothesis was proposed, the atmospheric scientific community has focused a substantial research effort along two general lines to test the hypothesis' correctness. The first is the development of a theoretical understanding of the response of the stratosphere to the emission of ozone-altering compounds, accompanied by process-oriented experimental observations that provide input to this model and appraisals of its validity. The second is a global, long-term monitoring effort designed not only to assist in the above development and testing, but also to search for direct observational evidence of the predicted human-caused perturbations of stratospheric ozone. The present status of these two endeavors are summarized separately in Sections II.B and II.C below.

B. GLOBAL OZONE DEPLETION THEORY

1. NOAA Current Research

NOAA has contributed to the development of this theory, as well as to the experimental appraisal of its validity. The NOAA theoretical work has taken two general directions. The first is a better understanding of the natural processes that form, distribute, and remove ozone, which give rise to the long-term natural background against which any human-caused trend will have to be identified. Sporadic and episodic events, such as bursts of solar particles, have provided natural short-term perturbations that have been used to test the theoretically predicted ozone responses. The second thrust is the development of improved models of the coupling of meteorology and chemistry, the results of which sounded an alert that ozone depletions are likely to be larger at higher latitudes than at the equator.

Shortly after the ozone-depletion hypothesis was proposed, NOAA's balloon-borne measurements demonstrated that the CFC's were indeed reaching the stratosphere in the quantities predicted by the theory. Laboratory studies revealed that some key reactions of the ozone-depleting chemistry were different than originally thought, thereby changing some aspects of the ozone-loss predictions.

Furthermore, long-term measurements of the atmospheric concentrations of the CFC's at remote global surface sites show that the worldwide abundance of these species is increasing, reflecting the growing atmospheric burden resulting from several years of generally increasing release rates. Lastly, NOAA's balloon and aircraft measurements of ozone-related stratospheric constituents have added to the data set against which the model calculations are being compared and hence evaluated.

2. Current State of the Theory

These theoretical and experimental studies of NOAA, as well as those of many others, have substantially increased the confidence in the basic structure of the ozone-depletion hypothesis. These features can be summarized as follows.

2.1 Natural Background Vis-à-vis Man-made Perturbations

Atmospheric ozone is predicted to respond to the total chlorine loading of the stratosphere, irrespective of the origin of the chlorine atoms. Direct stratospheric and tropospheric observations, reported production rates of chlorinated compounds, and transport and photochemical calculations yield a current lower-stratospheric chlorine abundance of about 2.8 parts of chlorine per billion parts of air (ppb), of which about 0.6 ppb is measured to be the natural background. The latter arises primarily from methyl chloride (CH_3Cl) emissions from the oceans. The lower-atmospheric abundances of the man-made chlorine compounds are observed to be increasing substantially; those of the natural compounds are not. Less is currently known about the bromine compounds, but a similar picture is emerging.

- **The man-made chlorine emissions to date have increased the stratospheric chlorine abundance by a factor of four over the natural background.**

2.2 Man-made Chemical Compounds

The man-made chemical compounds of primary concern in ozone depletion are a class of hydrocarbons, the alkanes [i.e., C_nH_{2n+2}; e.g., CH_4 (n=1) and C_2H_6 (n=2)], in which one or more of the hydrogen atoms have been replaced by a halogen [i.e., a chlorine (Cl), bromine (Br), or fluorine (F) atom]. An alkane with some, but not all, of the hydrogen atoms replaced by halogens is referred to as a partially halogened compound (example, CFC-22, which is CHF_2Cl). An alkane with all of its hydrogen atoms replaced by halogens is referred to as a fully halogenated compound (example: CFC-11, which is $CFCl_3$). As noted below, the degree of hydrogen-atom replacement and the particular halogens involved are the properties of the halogenated alkanes that determine their atmospheric and public-policy roles.

The overall factors governing the relative effectiveness of the emissions of a chemical compound to deplete ozone are:

(1) the rate of release of the compound into the atmosphere,

(2) the rate of removal of the compound in the lower atmosphere and its photodissociation rate in the stratosphere, and

(3) the efficiency of the halogen fragments in destroying ozone in the stratosphere.

Factors (2) and (3) combine to yield a quantity defined as a compound's ozone depleting potential (ODP). Table I gives calculated ODP values for examples of halogenated chemicals, along with their approximate 1985 global production rates and calculated atmospheric lifetimes.

Table I. Ozone-related properties of man-made halogenated compounds.

Group	Compound Name	Formula	Ozone Depleting Potential	Approximate 1985 Global Production Rate (million kg/yr)	Lifetime (yr)
(a)	CFC-11	$CFCl_3$	1.00	340	65
	CFC-12	CF_2Cl_2	1.1	440	130
	Carbon Tetrachloride	CCl_4	1.0	1050**	50
	CFC-113	$C_2F_3Cl_3$	0.8	160	90
	CFC-114	$C_2F_4Cl_2$	1.0*	very low	180
	CFC-115	C_2F_5Cl	0.6*	very low	380
(b)	Halon-1301	CF_3Br	10*	10*	110*
	Halon-1211	CF_2BrCl	3*	10*	25*
(c)	CFC-22	CHF_2Cl	0.08	210***	20
	Methyl Chloroform	$C_2H_3Cl_3$	0.1	550	7
(d)	CFC-123	$C_2HF_3Cl_2$	<0.05*	0	short*
	CFC-132b	$C_2H_2F_2Cl_2$	<0.05*	0	5*
	CFC-134a	$C_2H_2F_4$	0	0	10*

* Preliminary estimate.
** Greater than 90% is used as an intermediate chemical and hence cannot be released to the atmosphere.
*** A portion is used as an intermediate chemical (see **).
(Sources: UNEP, 1987; DuPont, 1987 and private communication.)

Group (a) contains fully halogenated chlorine compounds with ODP values near unity, where CFC-11 is the reference for the ODP scale. Group (b) consists of fully halogenated bromine compounds. Their ODP values are greater than unity, reflecting the fact that bromine atoms are considerably more effective in destroying ozone molecules than are chlorine atoms. The fully halogenated compounds of groups (a) and (b) have long atmospheric lifetimes because they are resistant to chemical reactions and hence removal in the lower atmosphere. Group (c) contains partially halogenated chlorine compounds. Their ODP values are substantially less than unity. These examples were in widespread commercial use in 1985. Group (d) contains partially halogenated compounds not produced in commercial quantities in 1985, but which may have potentially large applications in the future as possible substitutes for group (a) because they have ODP values significantly less than unity. The shorter lifetimes of groups (c) and (d) reflect the fact that their partial halogenation permits chemical removal from the lower atmosphere. Lastly, fluorine atoms play little or no direct role in ozone depletion [e.g., the ODP of $C_2H_2F_4$ (CFC134a) is zero].

Table I shows that, at present, CFC-11 and CFC-12 combined are the largest contributors, approximately 70%, to the predicted depletion of ozone and that CFC-113 contributes an additional 10%, where a compound's approximate contribution is the product of its ODP and production rate. It is clear that any proposed regulations that would allow substitution for CFC-11 and CFC-12 by other fully halogenated CFC's (e.g., CFC-114 or CFC-115) would not lower the risk to the ozone layer because of the large ODP values and the long lifetimes of these replacements. Although at current levels of production, a percentage reduction of CFC-11 and CFC-12 would lower the risk of ozone depletion more than an equivalent percentage reduction in the production of the other compounds listed in Table I, the high growth rates in the production of some of these other compounds (e.g., CFC-113 and the Halons) will be a source of concern if these rates continue over long periods of time.

- **From a scientific perspective, any proposed regulatory policy should consider all of the fully halogenated compounds [groups (a) and (b), which are characterized by high ODP's and long lifetimes] as a group for the purposes of regulation.**

- **Chemical compounds that have low ODP values, such as CFC-22 and those in class (d), may have significant value as possible substitutes.**

2.3 Emission/Production of the Halogenated Compounds

The input to stratospheric ozone models should be the total global emission rate into the atmosphere. Clearly, such data are not generally available because of the diverse emission modes (e.g., use of spray cans, leaking auto air conditioners, losses during servicing of refrigeration systems, diffusion out of insulating foams, and industrial releases). Approximate emission rates have been derived from reported annual production data and from estimates of the small unreported annual production, the allocation of production across the end uses, and the duration for which the compounds are stored in the various products. The left-hand portion of Figure 2 shows the estimated global annual emission rates through 1985 for the predominant fully halogenated chlorine compounds [group (a) in Table I].

Beyond 1985, three future growth-rate scenarios are depicted: a true global freeze at 1985 emission rates, a constant 1½% per year growth compounded annually, and a constant 3% per year growth compounded annually. The three are, of course, only hypothetical illustrative cases chosen for the purpose of examining a spectrum of predicted future stratospheric ozone responses. However, a glance at Figure 2 shows that they are not inappropriate choices, given the past emission rates. Moreover, a global freeze is a more realistic scenario than it first seems, since it is the net chlorine reaching the stratosphere (i.e., ODP) that is assumed constant. Clearly, this could be met by decreases in some sources and/or compounds to offset increases in others.

- **While the restrictions in the 1970's on the use of CFC's in aerosol sprays halted the rapidly increasing emission rates of the preceding decade, global emissions have begun increasing again in recent years.**

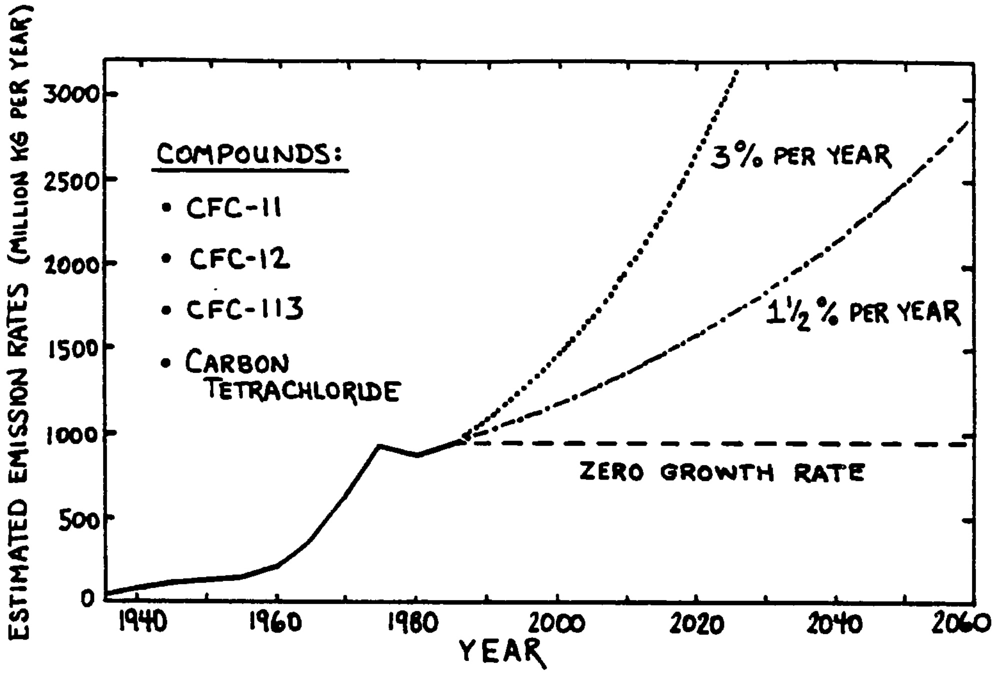


Figure 2. Estimated global annual emission rates of CFC-11, CFC-12, CFC-113, and carbon tetrachloride through 1985 and three hypothetical growth-rate scenarios. (Source: UNEP, 1987.)

2.4 Other Ozone-Related Trace Gases

The response of stratospheric ozone to chlorine emissions is sensitive to the abundances of other trace gases, notably carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The current theory predicts that increasing concentrations of carbon dioxide and methane increase the amount of ozone and those of nitrous oxide decrease it. Consequently, the predicted current and future ozone changes due to chlorine compounds depend on the current and future concentrations of these other trace gases. The source of CO_2 is predominantly fossil fuel consumption, and hence fuel-usage projections are the basis for establishing possible future emission-rate scenarios. The one most commonly adopted in theoretical assessments is a future growth rate of approximately 0.5% per year. The sources of CH_4 and N_2O are poorly understood at present, but there are both man-made and natural contributions. The currently observed growth rates are about 1% per year for CH_4 and 0.2% per year for N_2O. These are the future growth rates that are commonly adopted for CH_4 and N_2O in chlorine-perturbation calculations.

- **The predicted ozone response to chlorinated and brominated compounds is sensitive to the scenarios assumed for the future emissions of CO_2, CH_4, and N_2O. If the future growth rates of CO_2 or CH_4 are lower than assumed, then the predicted depletion of ozone would be greater. On the other hand, if the future growth rates of CO_2 and CH_4 are higher than assumed, then the predicted depletion would be lower.**

2.5 Atmospheric Retention Times of the Fully Halogenated Compounds

As noted, the only significant loss of the fully halogenated compounds is photodestruction in the stratosphere. Today, this loss rate is much smaller than the emission rates of these compounds; thus, their stratospheric abundance would continue to grow for many decades, even if their emissions plateaued or declined moderately. For example, with a freeze at current emission rates, the stratospheric chlorine abundance would plateau after several decades to approximately 8 ppb (about three times the present level and ten times the natural abundance). On the other hand, since the growth in the stratospheric chlorine abundance is slow, differences of a few years in the timing of emission restrictions cannot produce dramatically different predictions. The details depend, of course, on the particular scenarios studied.

- **From the standpoint of limiting the maximum concentrations of chlorine and bromine in the stratosphere, emission-rate restrictions done earlier need not be as severe as those done much later.**

3. Theoretical Predictions and Implications

Based on the current understanding of atmospheric chemistry, radiation, and circulation, the response of stratospheric ozone to chlorine, bromine, and other trace-gas emissions is reflected in changes in the following properties of atmospheric ozone:

- total column amount of ozone overhead,
- variation of this column ozone with latitude, and
- vertical distribution of ozone.

The predicted response of each of these ozone properties is described below. The emphasis is on delineating the types of response and the atmospheric processes involved, rather than on detailed assessment calculations for specific policy options.

3.1 Predicted Atmospheric Response: Changes in the Total Vertical Column of Ozone

The atmospheric response that has been the subject of most theoretical scrutiny is the predicted CFC-induced change in the total column of ozone overhead. This is certainly an understandable initial focus. It is the column ozone that determines the amount of ultraviolet radiation reaching the ground. It has been the potential ultraviolet-induced biological effects that primarily have fueled the public-policy discussions regarding CFC regulations.

Figure 3 shows the 75-year changes in the global average column ozone that current one-dimensional (i.e., altitude) models predict for the three growth-rate scenarios of chlorinated and brominated compounds: zero, 1½% per year compounded, and 3% per year compounded, beginning in 1985. Common to all three scenarios are the CO_2, CH_4, and N_2O increases cited above. The calculations include the species in groups (a), (b), and (c) of Table I (except for CFC-114 and CFC-115, whose current production rates are nearly zero).

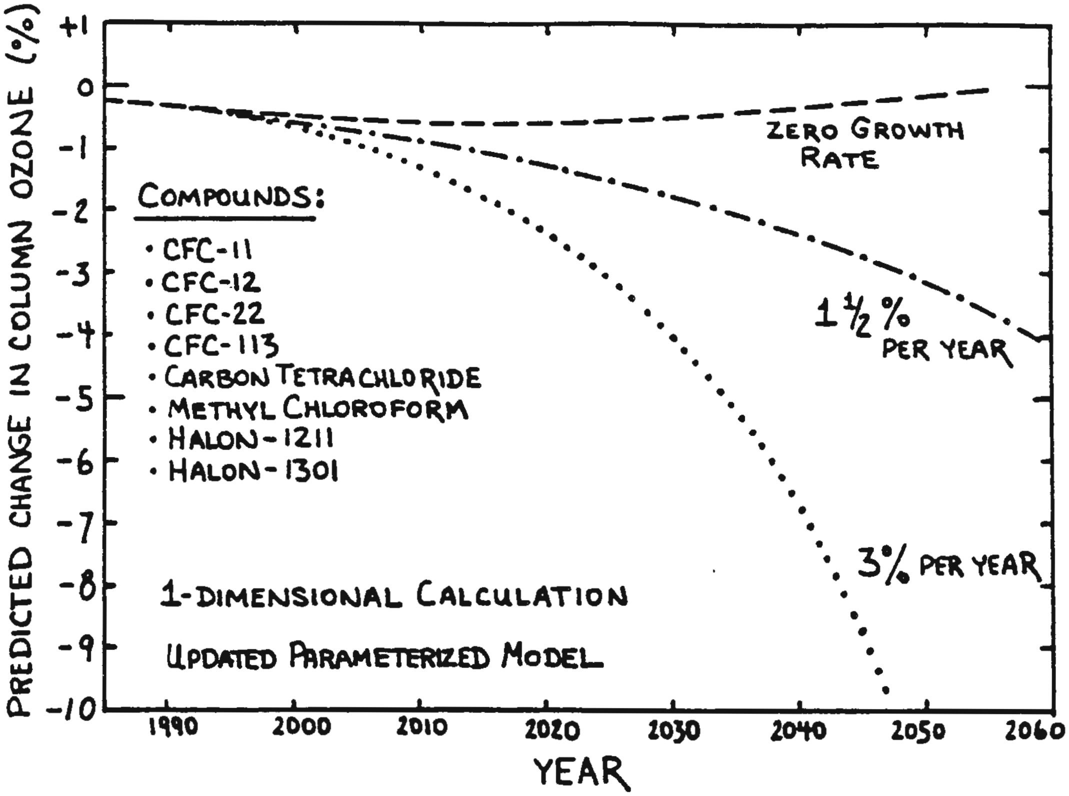


Figure 3. Predicted global average column ozone changes for three growth-rate scenarios of chlorinated and brominated compounds and continued increases of CO_2, CH_4, and N_2O emissions. (Source: UNEP, 1987.)

The global average column ozone depletion occurring in 1985 as a result of the emissions of chlorinated compounds during the preceding decades (see Figure 2) is predicted to be a fraction of a percent, as indicated in Figure 3. Furthermore, if the annual emission rates of the chlorinated and brominated compounds were to remain constant at the 1985 levels, the future column ozone loss is predicted to be approximately a percent or less over the next 75 years. In this case, the ozone losses due to the constant chlorine and bromine emissions are eventually offset by the ozone production due to the increasing CO_2 and CH_4 emissions. If the adopted CH_4 growth rate had been 0.5% per year (rather than 1%), the offsetting effect would be less and the predicted column ozone depletion would grow to 2% by the year 2060. (This alternative scenario is not shown in Figure 3.)

For the two scenarios in which emissions grow at 1½ and 3% per year, Figure 3 shows that the effect of the increasing chlorine/bromine concentrations dominates, and hence the column ozone loss grows steadily with time. Different one-dimensional models yield similar results. Furthermore, other emission-increase scenarios also show the same features, but, of course, differ in degree. The salient points of such emission-increase scenarios remain the same, which are the following.

The current understanding of the response of stratospheric ozone to increasing chlorine and bromine abundances predicts that a 3% annual growth rate risks a very large global-average column ozone depletion after 75 years. A 1½% annual growth rate is predicted to induce a 4% loss. Although public policy has not yet set an "acceptable" ozone loss, such growth rates risk a man-made perturbation that is comparable to or greater than what measurements indicate may be the decadal natural column ozone variation: 3 to 4% (see Figure 7 below and the associated text).

- **A freeze of total chlorine and bromine emission rates is consistent with limiting predicted long-term perturbations in the global average column ozone to magnitudes less than the decadal natural variation, which is about 3 to 4%.**

3.2 Predicted Atmospheric Response: Latitudinal Dependence of Column Ozone Changes

The current theoretical understanding of the interaction of global circulation patterns and ozone chemistry predicts that more column ozone loss will occur at higher latitudes than at the equator. This latitudinal dependence has been examined with several different two-dimensional (i.e., altitude and latitude) models, with consistent results. Figure 4 shows this predicted variation with latitude for a freeze in CFC-11 and CFC-12 emissions, beginning in 1980, and continued growth in CH_4 and N_2O emissions. The predicted column ozone depletions in the springtime (when the effect is a maximum) for the high latitudes are two to three times larger than the predictions of one-dimensional models. Therefore, even with a global freeze, column ozone losses of several percent are predicted to occur at the high-latitude locations (e.g., Alaska and Scandinavia) after 75 years.

- **A significant decrease in total chlorine and bromine emission rates is consistent with limiting predicted long-term perturbations in the column ozone at high latitudes to magnitudes less than decadal natural variation.**

3.3 Predicted Atmospheric Response: Changes in the Vertical Distribution of Ozone

Current one- and two-dimensional models predict that, even when there are only small changes in column ozone, there would still be substantial changes in the vertical distribution of ozone due to the combined effects of increasing concentrations of chlorinated and brominated compounds and of CO_2, CH_4, and N_2O. Figure 5 illustrates this point with an example. Shown are the long-term percentage changes in local ozone for altitudes up to 50 km that are predicted for two CFC-11 and CFC-12 growth-rate scenarios: zero and 1½% per year compounded, beginning in 1980, and with continued increases in CO_2, CH_4, and N_2O emissions.

The percentage changes in local ozone are negative in the upper stratosphere and are positive in the lower stratosphere and below. For the scenario of 1½% growth rate, the upper-stratospheric ozone loss is greater than the ozone production at the lower altitudes, and hence the predicted long-term change in the total column ozone is a substantial depletion, similar to that

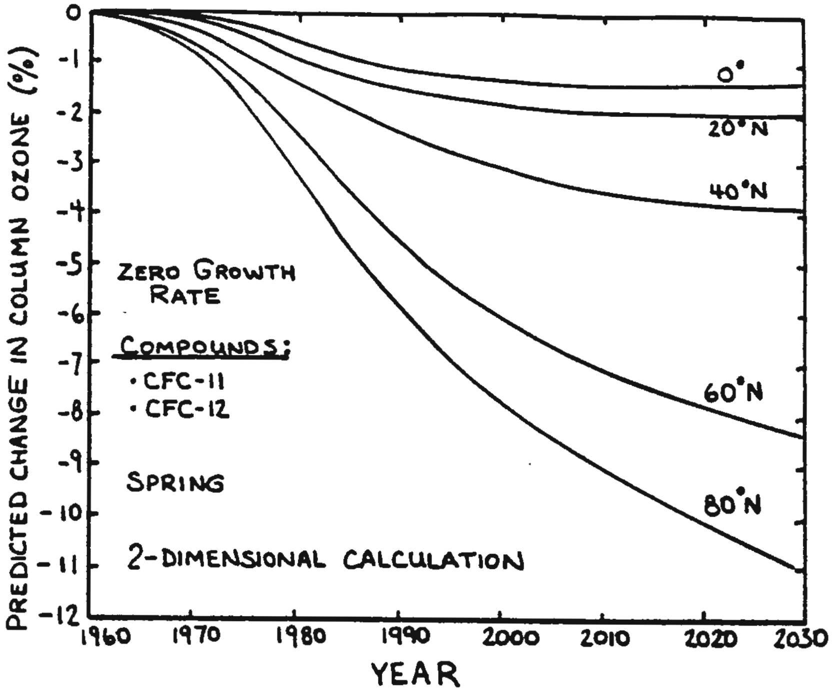


Figure 4. Predicted depletions in the column ozone for various latitudes for a freeze in CFC-11 and CFC-12 emissions at 1980 levels and continued increases of CH_4 and N_2O emissions. Note: These are likely to be upper limits since the calculation did not include CO_2, whose offsetting effect would probably reduce the predicted depletions by about 30%. (Source: UNEP, 1986).

depicted by the dot-dashed curve in Figure 3. For the emissions-freeze case, there is near cancellation of the ozone losses in the upper stratosphere and the ozone production in the lower atmosphere. Hence, the predicted net change in the column ozone is nearly zero, similar to that depicted by the dashed curve in Figure 3.

Nevertheless, even though a global freeze is predicted to preserve the total ozone column within a few percent, the depletion in the upper stratosphere and the production at lower altitudes are themselves potentially of environmental significance. Each change arises from different processes and has different possible consequences. These are examined separately in Figure 6, which depicts the emissions-freeze case.

Upper-stratospheric ozone decrease

The upper parts of the solid curve and hatched area in Figure 6 shows that the long-term <u>depletion</u> of local ozone at 40 km is predicted to be about 25%. The dashed curve shows the depletions that are predicted for the CFC's alone, i.e., no effects of CO_2, CH_4, and N_2O. As indicated, the predicted

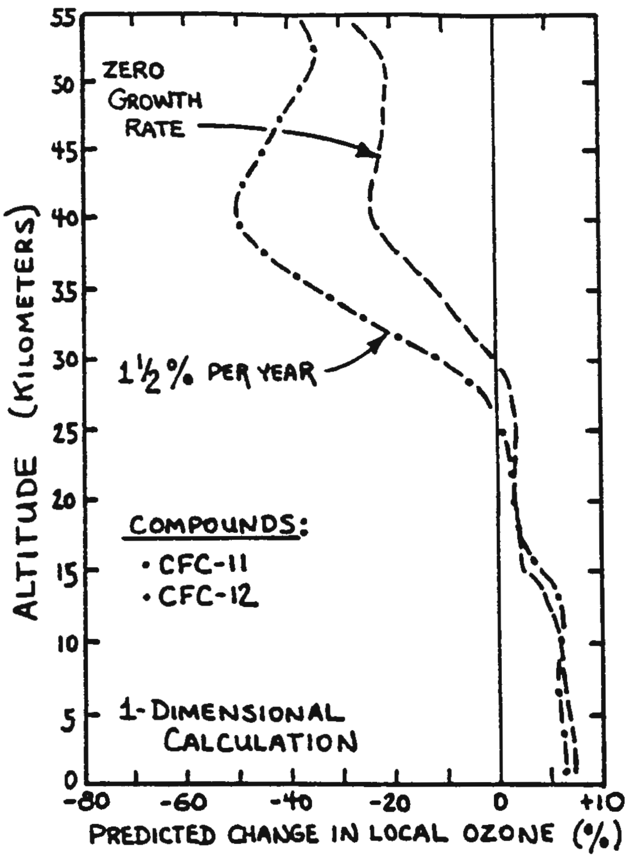


Figure 5. Predicted long-term changes in the vertical distribution of ozone for two CFC-11 and CFC-12 growth-rate scenarios and continued growth of CO_2, CH_4, and N_2O emissions. The steady-state values that are reached are 8 and 15 ppb chlorine, respectively; doubled CO_2 and CH_4; and a 20% increase in N_2O. (Source: WMO, 1985.)

depletion would be much larger were it not for the ameliorating effect of the other trace gases, primarily CO_2, namely, a cooling that slows the temperature-dependent, natural ozone-destruction reactions.

The current understanding of the consequences of such a 25% ozone decrease is that it may produce a local temperature decrease of 5°C. The possible effects of such a cooling on stratospheric circulation patterns are current research topics.

The comparison of this predicted cooling to natural temperature variations is hampered by the lack of long-term temperature records at these altitudes. However, limited rocketsonde data for the western portion of the northern hemisphere suggest a decadal temperature decrease of 1-2°C. All of this decline may not be purely a natural variation, since some scientists claim that human-caused CO_2 increases may be responsible for part of this cooling trend of the past decade. Nevertheless, a global freeze on chlorine and bromine emissions is predicted to allow upper-stratospheric temperature changes that are several times larger than what is currently the only estimate of decadal natural variation at those altitudes.

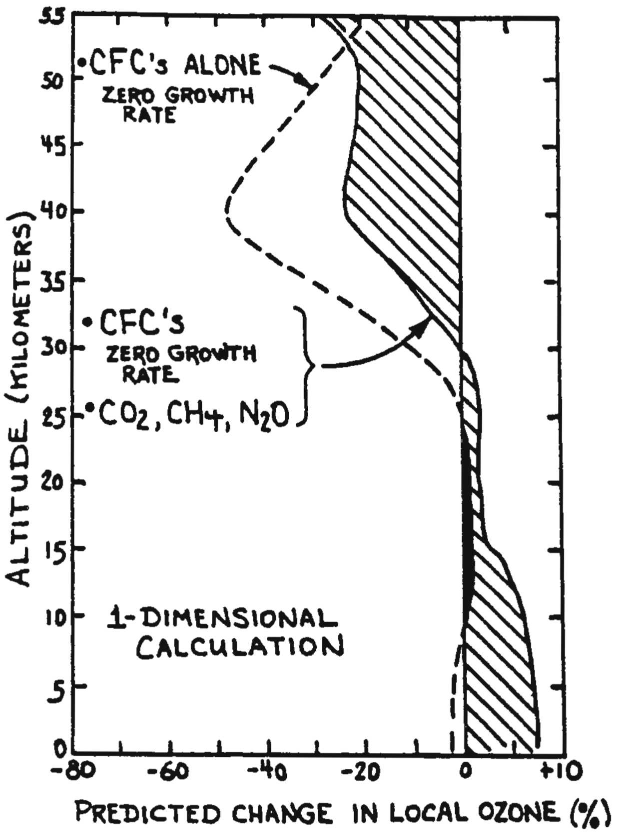


Figure 6. Predicted long-term changes in the vertical distribution of ozone for a constant emission rate of CFC-11 and CFC-12 since 1980 and continued growth in CO_2, CH_4, and N_2O emissions (solid curve). The dashed curve reflects the predicted changes due to the CFC's alone (constant 1980 rates). The steady-state abundances that are reached are 8 ppb chlorine, doubled CO_2 and CH_4, and a 20% increase in N_2O. (Source: WMO, 1985).

- **A significant decrease in total chlorine and bromine emission rates is consistent with limiting predicted long-term losses in the ozone at 40 km and associated decreases in local temperatures to magnitudes comparable to or less than the current (limited) observations of decadal natural variation, which is about 1 to 2°C.**

- **However, the couplings and feedbacks of chemistry, radiation, and circulation in the upper stratosphere have yet to be represented fully in three-dimensional models. Furthermore, the possible effects of the predicted upper-stratospheric cooling on life at the earth's surface are unknown at present.**

Lower-atmospheric ozone production

The lower parts of the solid curve and hatched area in Figure 6 highlight the long-term ozone production that is predicted to occur below 25-30 km from constant 1980-level emissions of the two CFC's and continued increases in the emissions of the other trace gases, primarily CH_4. The lower dashed curve and the solid area identify the portion of the predicted ozone increase that is due to the presence of CFC's alone, namely, the ozone production resulting from enhanced ultraviolet radiation at those lower altitudes (a consequence of upper-stratospheric ozone losses). The area that is the difference between the hatched and solid areas represents the ozone that is predicted to be produced photochemically from CH_4. Because of the complexities of the chemistry in the lower atmosphere (e.g., regional pollution effects), there is substantial uncertainty in this prediction.

The potential consequence of such ozone production, particularly those in the region of the temperature minimum at 10-15 km, is an enhanced "greenhouse effect". Specifically, at the higher pressures of the lower atmosphere, ozone absorbs infrared radiation from the earth and radiates a fraction of this outgoing energy back to the surface, thereby elevating the temperature.

Like CO_2, the CFC's and CH_4 are also "greenhouse molecules". Therefore, the CFC's and CH_4 contribute both directly and indirectly to "greenhouse" warmings, the latter being the associated increases in lower-atmospheric ozone. Current radiative models predict that the emissions of CFC's through 1980 have committed the planet to an eventual warming that is about 10% of that produced by the past CO_2 emissions, (i.e., about 10% of 0.6°C). Essentially all of this CFC contribution is believed to be due to their direct "greenhouse" role. The time delay in the arrival of the warmer surface temperatures is due primarily to the thermal inertia of the oceans.

There is a distinct need for new global-warming calculations to be made for trace-gas scenarios that are under public discussion presently, e.g., a global freeze in the late 1980's on the fully halogenated compounds. Based on the limited number of future emission scenarios that have been examined in radiation models, it is estimated that a freeze of CFC-11 and CFC-12 emissions at the present rates would have committed, by the year 2030, the planet to a direct and indirect greenhouse warming that could be (very approximately) a fourth of that due to CO_2 (i.e., about 1/4 of 1.3°C). The uncertainties in the long-term predictions of current climate models is probably a factor of three, due primarily to the incompleteness with which the cloud feedback processes can be incorporated at present.

Surface temperature changes have been measured directly for about a century and have been inferred from tree-ring variations for an additional century and a half. This 250-year record reveals natural variations of ±0.5°C, with changes of 0.5°C occurring on both decadal and centennial time scales. Thus, the approximate 0.3°C long-term warming that is predicted to be associated with a 1980's freeze of CFC emissions is comparable to the observed long-term natural variations.

- **A decrease in the total emission rates of chlorinated and brominated compounds is consistent with limiting their predicted commitment to a long-term "greenhouse" warming such that it is less than the decadal natural variation, which is about 0.5°C.**

3.4 Uncertainties in Predictions

All of the responses examined above are the results of theoretical predictions. If they are to be taken as forecasts of how the atmosphere will actually behave over the next 75 years, then the uncertainties in these forecasts arise from two primary sources:

(1) the inability to forecast what the actual trace gas abundances will be and

(2) deficiencies in the framework of the theoretical models of the atmosphere.

For the first, the issue is not so much the future production rates of the chlorinated and brominated compounds, since the current public-policy discussions are examining the various scenarios of these emissions as regulatory options. Rather, this source of uncertainty arises from the inability to forecast the future CO_2, CH_4, and N_2O abundances, which are outside of the present policy discussions. The effect of this uncertainty is highlighted by recognizing that the small global average column ozone change in the scenario for zero growth of the fully halogenated compounds in Figure 3 is a cancellation of multiple trace-gas effects.

The second source of uncertainty, model deficiencies, is more subtle and difficult to assess. While the current satisfactory consistency between the predictions of different models is very gratifying, it cannot be taken as proof that all important atmospheric processes are known and have been correctly included. The basic test of a model is that it closely simulates the observed ozone-related features of the present atmosphere. Many of these features have been characterized by observations. Disagreements between a few of the observations and model predictions do exist, which places some limits on the confidence in the predictive abilities of the models. A particularly unsettling discrepancy is the apparent underprediction by about 30% of ozone itself in the upper stratosphere. Furthermore, the treatment of dynamical processes in the two-dimensional models is still a subject of current research. However, in general, there is good agreement between observations and predictions for a large number of atmospheric features.

- **Since stratospheric ozone is sensitive to changes in other trace gases besides chlorinated and brominated compounds, an additional uncertainty in the assessments of possible man-made perturbations is the difficulty in predicting the future abundances of the other trace gases, particularly CO_2 and CH_4.**

- **While the models based on the present theories simulate much of the present stratosphere quite well, they are not perfect, which places a factor of two to three uncertainty on their predictive abilities.**

- **Nevertheless, based on present understanding, most atmospheric scientists believe that if the present growth rates of chlorinated and brominated compounds continue unabated indefinitely, then it is highly likely that substantial ozone depletions will occur in the next century, particularly at the higher altitudes and latitudes.**

4. NOAA Future Research

NOAA research will continue to focus on reducing the uncertainties in the predictions of possible stratospheric ozone perturbations. The major emphases will be the following near-term research efforts:

- In collaboration with the National Aeronautics and Space Administration (NASA), the reactive nitrogen content of the lower stratosphere will be measured in both hemispheres with an instrumented research aircraft. The reactive nitrogen sources, abundance, and latitudinal distribution are important parameters in controlling the rate of chlorine-induced ozone loss.

- The processes by which ozone-related compounds are exhanged between the stratosphere and the lower atmosphere will be characterized better by direct airborne measurements (in collaboration with NASA) and accompanying theoretical investigations.

- CFC-113, CFC-22, Halon 1301, and Halon 1211 are being added to the ground-based monitoring program. The atmospheric abundances of these species are the fastest growing of the chlorinated and brominated compounds.

- Theoretical simulation of ozone-influencing atmospheric circulation will be improved with higher resolution in three-dimensional models, thereby better defining the scales of ozone variation.

- An improved treatment of radiation will be incorporated into one- and two-dimensional models and tested by making vertical-distribution measurements of solar radiation.

- Interactive three-dimensional models of ozone with climatic feedbacks will be explored, with an emphasis on improving the understanding of the interactions between CO_2, ozone, and temperature changes.

C. GLOBAL OZONE DEPLETION OBSERVATIONS

Similar to the advance of the theory of the stratospheric ozone response to chlorine and bromine emissions, there has been substantial effort to monitor the variation of ozone in order to detect human-caused depletions.

1. NOAA Current Research

NOAA has contributed to this accumulating data base that shows how the stratospheric ozone abundance varies in space and time. Specifically, NOAA scientists are operating several ground-based "Dobson" instruments that monitor the total amount of ozone overhead and that estimate how it is distributed vertically (via the "Umkehr" method). Balloon-borne ozonesondes are also providing regular measurements of the vertical distribution at selected sites. In addition, NOAA has a Solar Backscatter Ultraviolet instrument (SBUV-2) on its TIROS satellite series that, once the testing is complete, will provide similar information on a global scale. This instrument represents a monitoring continuation of the NASA research version (SBUV-1) launched several years earlier on the NIMBUS 7 satellite. NOAA scientists are among the analysts who scrutinize this accumulating data base for trends arising from natural variation and for the first signs of possible human-caused depletions.

2. Current State of the Observations

As explained above, current models predict that the present global column ozone depletions due to the past emissions of chlorinated compounds should be small, less than a percent (see Figure 3). At high latitudes, the predicted current column ozone depletions are probably less than a few percent (see Figure 4). Based on one-dimensional, time-dependent calculations similar to those leading to Figure 5, the predicted current ozone depletions at 40 km, which is where the percentage changes due to chlorine chemistry are expected to be the largest, are approximately five percent. How consistent are these predictions with the present stratospheric ozone data record?

2.1 Global-Average Column Ozone Changes

Column ozone observations are the longest-running ozone record. The ozone column has been observed both from above and below.

Ground-based observations

The ground-based Dobson network, which currently consists of approximately 85 stations, has provided global column ozone data from about 1960 to the present. The 25-year record up through 1985 is given in Figure 7.

The center portion of Figure 7 shows the temporal behavior of the average column ozone for the globe. The biennial variation is evident in this data set, as are longer-term trends over decades. Global column ozone increased by about 3% through the 1960's, remained more invariant during the 1970's, and has decreased about 4-5% in the 1980's.

There are individual Dobson stations that provide a longer data record. The most notable of these is Arosa, Switzerland, whose measurements began in 1932. These data suggest that column ozone was, at that site, about 3% lower during the decade of the 1930's compared to that of the 1970's.

The experimental uncertainty in the Dobson technique has been examined extensively. The relative accuracy (i.e., for trend determinations) is considered to be 1-2%. Consequently, it is very likely that much of the variation shown in Figure 7 truly reflects changes in global ozone.

Satellite observations

The SBUV-1 instrument on the NIMBUS 7 satellite has made measurements of column ozone since 1979 and provides far more extensive global coverage than the Dobson data set. Unpublished accounts of the satellite data cite a 7.4% decrease in global column ozone over its eight-year record. The overall calibration of the SBUV-1 sensor is known to be drifting since launch, making this estimate very uncertain. One way to account for this drift is to correct for it by matching the data to the ground-based Dobson measurements for the limited number of overpasses of the network sites. This recalibration results in a

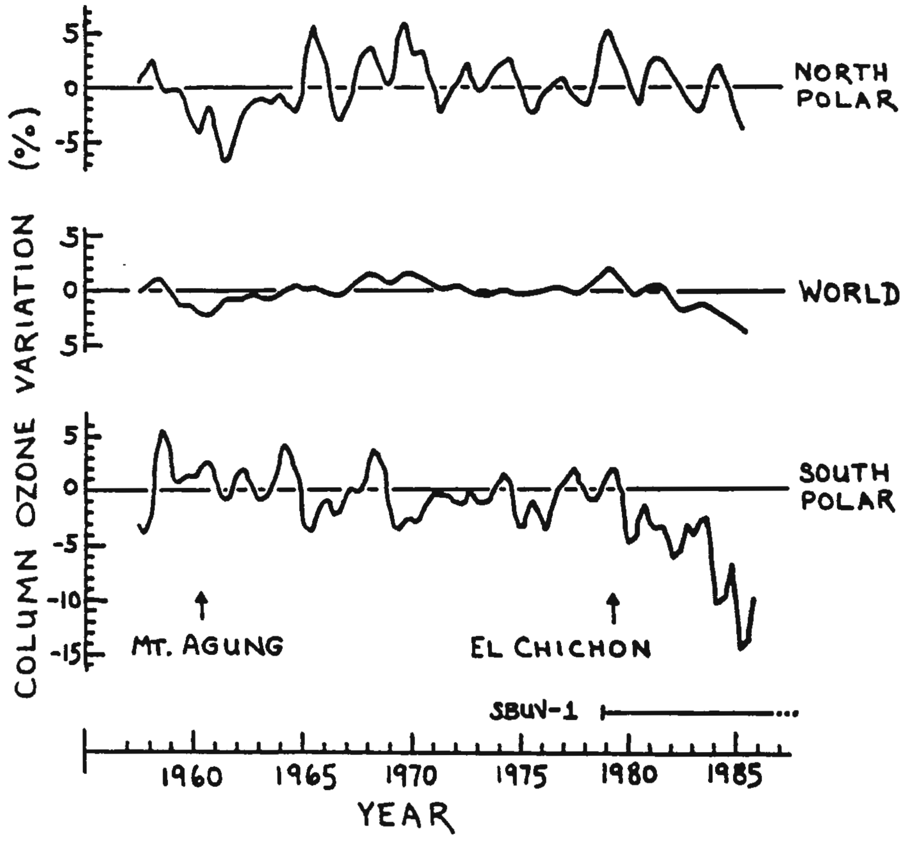


Figure 7. Seasonally averaged column ozone observed by the ground-based Dobson network. The occurrence of several potentially ozone-altering events are noted. The measurement period of the SBUV-1 satellite instrument is also indicated. (Source: Angell, 1987.)

4.4% decreasing trend. Therefore, the spatially limited number of Dobson data and the globally extended satellite observations show the same downward trend from 1979 to 1985, if this recalibration is adopted.

Interpretation

Thus, both the ground-based Dobson data and the satellite data demonstrate that global column ozone changes on several time scales. A variety of possible radiative, chemical, and dynamical causes have been considered, both natural and man-made: variation in solar output radiation, episodic aerosol injection from major volcanic eruptions like El Chichon in 1982, circulation anomalies like the major El Niño - Southern Oscillation event in 1982-83, the chemical perturbations introduced by the atmospheric nuclear bomb tests in 1961-62, and the growing stratospheric abundance of man-made chlorine compounds during the last decade. For obvious reasons, considerable attention has been focused on the downward trend that began about 1979. The question is not whether an ozone decrease is indeed occurring. Experimentally, there is little doubt about this. Rather, the question relates to why. Specifically, how much of this global decrease in column ozone is due to a depletion caused by man-made chlorine compounds?

If the 3% increase of the sixties is due to unexplained natural variation (and not a possible recovery from the 1961-62 bomb tests), then it cannot be ruled out that the 4-5% decrease of the last decade also may be due largely to such variation. Indeed, analyses of these data, which include an accounting for the external ozone forcing by solar activity, do not reveal any statistically significant ozone depletions in recent years. Specifically, the solar sunspot cycle was in a strongly decreasing phase over this period, which may account for about 2% of the decline. Furthermore, about 1% is due to the large loss in a specific region, Antarctica (which is examined in Section III below). Thus, there is an "unexplained" decrease of less than 2% in global ozone over the seven years as evidenced by the Dobson and satellite data. When this 1-2% unexplained decrease is considered against the observed variability seen in the 25-year Dobson record, there appears to be no inconsistency in accepting that this is within the range of natural variation, and hence it alone cannot be considered as conclusive evidence of an anthropogenic influence.

This conclusion is consistent with the current theory of stratospheric ozone chemistry, which predicts that the present global column ozone depletions due to past releases of chlorinated compounds should be less than 1% (see Figure 3). A depletion of this magnitude would be very difficult to identify against the background of poorly understood natural variation. It is particularly ironic that, during the period 1979-1985 over which the Dobson and satellite data are being intently scrutinized for a possible chlorine-induced ozone loss, two major geophysical events of the century occurred: El Chichon's 1982 eruption and the 1982-1983 El Niño.

Current theory predicts that the chlorine-induced column ozone depletion should be larger at high latitudes, perhaps a few percent by 1985 (see Figure 4). The upper part of Figure 7 shows the Dobson data record for the north polar region. No downward trend for the last decade is obvious, although the larger biennial oscillation at these latitudes and the uncertainty introduced by the limited number of stations (three) make it difficult to judge. There are unpublished comments regarding column ozone depletions at the northern latitudes based on the SBUV-1 data, but without the opportunity to examine the details, it is difficult to assess their meaning. Thus, there is no unequivocal observational evidence of a decrease in column ozone at high latitudes. This does not "disprove" the chlorine-induced ozone-depletion theory, since the predicted current depletions, even at high latitudes, are still relatively small compared to the short-term variations in the published ozone data.

Discussion of the lower part of Figure 7 is deferred until Section III below.

2.2 Ozone Vertical-Distribution Changes

Although the existing data record for the vertical distribution of ozone is not as long as that for the column ozone, it does begin to offer the opportunity to search for a possible chlorine-induced "signature" in the trends. The vertical distribution of ozone has been measured by ground-based, balloon-borne, and satellite instruments.

Ground-based observations

The Umkehr variation of the Dobson method provides estimates of the altitude distribution of ozone. Hence, a time series of Umkehr data can reveal the temporal change in local ozone at different stratospheric altitudes. The method has been applied consistently only since about 1967, so the 18-year data record is about three-quarters that of column ozone from the Dobson network. Currently, there are 13 Umkehr stations. Figure 8 shows the temporal variation of ozone in two altitude layers above the north temperate latitudes (where most of the Umkehr sites happened to be located).

Current theory predicts that the largest altitude-dependent ozone depletions due to chlorine emissions should be in the 48-32 km altitude region (see the discussion associated with Figure 5). Indeed, if these data are taken at face value, they exhibit a distinct overall downward trend of about 5% over the past decade. Moreover, the data for the lower altitudes, 32-24 km, show no significant trend.

Balloon-borne observations

Until recently, almost all of the sites at which ozonesondes are launched regularly have been at the north temperate latitudes. There are currently about 12 such sites, and the data extend back to 1967. Therefore, the temporal and spatial coverage of the ozonesonde network is limited much as the Umkehr network is. In addition, the accuracy with which the expendable sondes can measure ozone deteriorates in the upper stratosphere. Hence, there is a dearth of reliable trend data from ozonesondes in the critical 48-32 km alti-

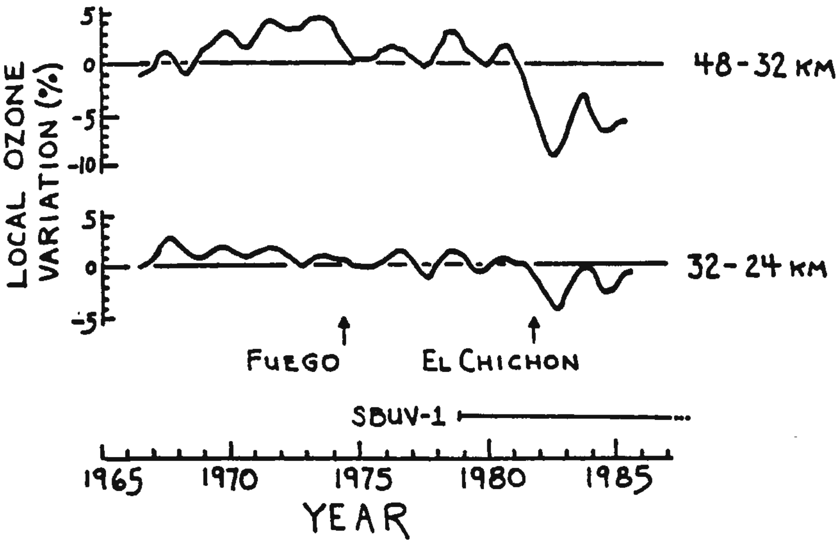


Figure 8. Ozone in the 48-32 and 32-24 km altitude ranges observed by the Umkehr stations in north temperate latitudes. The arrows denote the dates of the indicated volcanic eruptions, and the measurement period of the SBUV-1 satellite instrument is also noted. (Source: Angell, 1987.)

tude range. However, the sonde data for the lower layer, 32-24 km, do provide a valuable confirmation of the Umkehr finding of the absence of any prominant trend.

Satellite observations

The SBUV-1 instrument, in addition to column ozone, can yield the vertical ozone distribution, in a fashion similar to that of the Umkehr method. Hence, its 8-year data record potentially can yield the temporal trends of ozone over a range of altitudes and latitudes. Unpublished statements refer to a 15% decrease of global-average ozone at 45 km over the past eight years and a 7% decrease at 33 km. The average of these decreases is about twice as large as the decline based on the Umkehr data for the 48-32 km layer. The ozone decreases reported tended to be larger at higher latitudes.

Interpretation

The Umkehr data record shows ozone decreases that are consistent with the theoretical predictions based on past chlorine emissions, namely, about 5% decadal loss of ozone in the upper stratosphere. This record is the strongest of the existing observational evidence that supports the reality of current ozone loss due to man-made chlorine compounds. However, it is not without its uncertainties. As noted by the arrows in Figure 8, two major volcanic eruptions occurred during this time period. The Umkehr technique is quite sensitive to interference by stratospheric dust. Corrections must be made using ground-based lidar data on the vertical dust distribution. Only a few Umkehr sites have accompanying lidars; hence, the correction must often be made using assumed dust distributions. As a result, the uncertainties of this data set are difficult to quantify.

The most thought-provoking data set of ozone vertical distributions is the unpublished record from the SBUV-1 satellite instrument. Since the larger ozone decreases are associated reportedly with the higher altitudes and latitudes, key features of the chlorine-induced ozone losses would appear to be present. If these measurements are indeed correct, the magnitude of this reported decrease is substantially larger than what current theory is predicting, which would imply model deficiencies. However, these data are not yet accepted by the scientific community. The calibration difficulties have been discussed above. Since the global three-dimensional coverage afforded by a satellite provides a very sensitive way to search for the predicted chlorine induced "signature", the correctness of these data is a pressing issue that needs to be settled.

3. Implications of the Trends Observations

The stratospheric scientific community currently is divided as to whether the existing data on ozone trends provide sufficient evidence to believe that a chlorine-induced ozone destruction is occurring now. The main points for and against are as follows:

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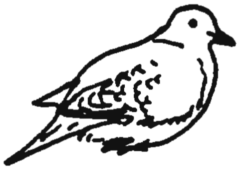
The current global stratospheric ozone data record DOES show compelling evidence of a chlorine-induced ozone depletion:

- Global column ozone is lower now than it has been at any time since such observations began.
- Indeed, the steepest downward trend of global ozone of extended duration that has been seen over the past 25 years of the Dobson network is the decrease that has been occurring over the last few years, which is the period of increasing stratospheric chlorine abundance.
- The data from the SBUV-1 satellite instrument indicate that the recent global column ozone decrease may be even larger than originally believed.
- The ozone vertical-distribution data record from the Umkehr network show ozone decreases in the upper stratosphere over the past decade that agree both in magnitude and altitude with the predictions of the chlorine-induced ozone-depletion theory.
- The SBUV-1 vertical-distribution data show ozone decreases over the past eight years that are larger at high altitudes and latitudes, a pattern that agrees with the chlorine-induced theory.
- The magnitudes of these high-altitude and high-latitude ozone decreases are even larger than theory predicts!

- 

The current global stratospheric ozone data record DOES NOT show compelling evidence of a chlorine-induced ozone depletion:

- When the whole Dobson data record is considered, there is no compelling statistical evidence of a chlorine-induced ozone depletion of global column ozone, even at high latitudes, during the last several years.
- In particular, the often-cited time period of 1979-1985 includes four unique natural anomalies and potential ozone perturbations: (a) it began with the highest global column ozone on record, (b) it contained the powerful El Chichon volcanic eruption, (c) it included the

strong 1982-83 El Niño, and (d) it spanned a period of strongly decreasing solar output. The one possible man-made contribution to the 4-5% ozone decrease of this period cannot, at present, be distinguished from the potential contributions of these natural causes.

- The SBUV-1 data for 1979-1985 do not show unequivocally larger column ozone decreases than the Dobson data. Specifically, the SBUV-1 instrument has no onboard calibration standard, and hence the known drift in the sensor's sensitivity is difficult to account for unambiguously. When the SBUV-1 data are calibrated with those from the overpassed Dobson sites, the two data sets, which are vastly different in spatial coverage, yield consistent global column ozone trends.

- The upper-stratospheric Umkehr data of the past decade neither confirm nor disprove the chlorine-induced ozone-depletion theory. This method of obtaining ozone vertical distributions is very sensitive to volcanic dust, such as that from El Chichon. The uncertainties introduced from incomplete corrections for this effect are not well-quantified.

- The large downward ozone trends at high altitudes and high latitudes that are reportedly in the SBUV-1 data cannot be accepted as proof of a chlorine-induced ozone depletion. These results have not been published yet. As a result, they have not yet had the scrutiny of the scientific community that they clearly deserve, particularly in light of the calibration difficulties.

- Lastly, the unpublished statements regarding this data set appear to have an internal contradiction: the chlorine-induced ozone-depletion theory is evoked to explain the observed pattern of the high-altitude, high-latitude ozone decreases, but it is rejected as insufficient in explaining the magnitude of those decreases. One is not allowed to play it both ways!

It is clear that "the jury is still out" on the implications of observed stratospheric ozone trends.

4. NOAA Future Research

NOAA's ozone-trends research will continue to focus on improving the monitoring record. Specifically, the near-term research will consist of the following tasks.

- Participation in the Dobson and Umkehr networks obviously will continue. It is particularly important to establish the future near-term behavior of the present sharp downward trend in global column ozone and upper-stratospheric ozone.

- NOAA Dobson and Umkehr sites will be improved. In particular, expanded lidar measurements of the stratospheric dust distribution will increase the accuracy of ozone data.

- NOAA will continue to implement the current SBUV-2 instrument on the TIROS satellite, to plan to extend these types of measurements through the mid-1990's, and to design an improved instrumental system for monitoring ozone and other related species on future satellite series after TIROS.

- NOAA scientists have joined colleagues from NASA, the Chemical Manufacturers Association (CMA), and several universities in an independent evaluation of the existing Dobson, Umkehr, and satellite data sets. The goal is to address the inconsistencies, reanalyze data, intercompare in detail, re-estimate uncertainties, and put together, insofar as possible, a consistent picture of global ozone trends and their implications by the end of 1987.

- NOAA has joined NASA and CMA in planning a ground-based network of several sites that will use modern remote-sensing techniques to detect stratospheric change and will employ expanded data-handling and assimilative capacities to aid and speed interpretation. The results will have several critical and immediate payoffs. First, the covariation of several stratospheric chemical species and properties is key input to improve theory, as well as providing an assessment of its adequacy. Moreover, the data would serve as the absolute calibration for satellite sensors, provide an independent monitoring system for quality-control intercomparisons with the satellite systems, act as backup in case of satellite or launch-vehicle problems, and include chemical species not obtainable presently by satellites.

III. ANTARCTIC STRATOSPHERIC OZONE DEPLETION

A. THE PROBLEM

In contrast to the search for the small beginnings of the predicted global chlorine-induced ozone loss and the debate over its reality, an unprecedented and unanticipated phenomenon was discovered recently that has riveted the attention of ozone scientists, policy makers, industrialists, and environmentalists alike, namely the Antarctic "ozone hole". Here, the amount lost is considerable -- half of the ozone over Antarctica disappears or fails to appear in a very puzzling fashion -- and the agreement between the ground-based, satellite, and balloon-borne ozone data for that region leave no doubt about the reality of this phenomenon.

The data that revealed the existence of the phenomenon are shown in Figure 9. In the Antarctic spring (and only there and only at that season), a substantial fraction of the column ozone disappears. The fractional decrease has increased, on the average, over the past several years. The magnitude of the decrease and the nature of its occurrence could not be explained by previously existing ozone-loss theory (i.e., that described in Sections IIA and IIB). The fact that nothing of this magnitude had occurred earlier in the south polar latitudes is shown by the 25-year column ozone record given in the lower part of Figure 7. Indeed, this recent decrease in Antarctic ozone discovered by the British Antarctic Survey is far larger than the variability observed at any time anywhere on the globe. What is causing it?

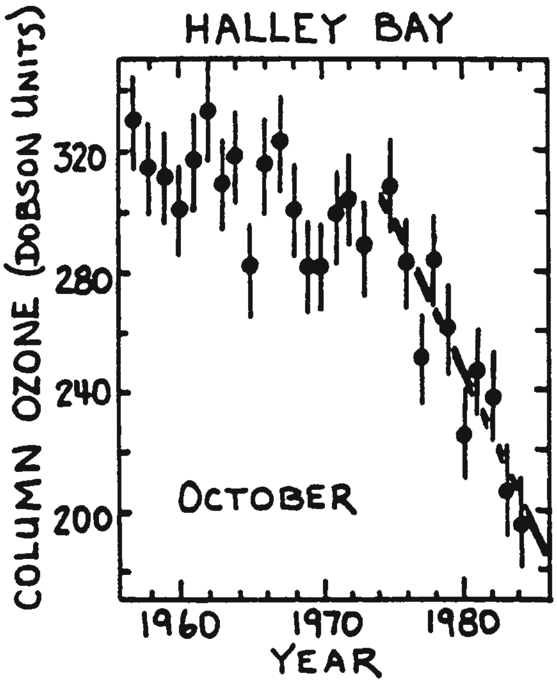


Figure 9. Column ozone observations by the British Antarctic Survey at Halley Bay, Antarctica, in the austral spring. (Source: Farman, Gardener, and Shanklin, 1985.)

- **The existence of growing and substantial seasonal losses of ozone in the Antarctic stratosphere is established beyond doubt and is unique among ozone observations.**

B. CURRENT STATE OF THE SCIENCE

1. NOAA Current Research

NOAA researchers have responded to this puzzle with new theoretical and experimental studies. Shortly after the discovery of the "ozone hole" was announced by the British Antarctic Survey in 1985, NOAA scientists sought to explain this dramatic phenomenon in terms of two separate theories: natural climate change and man-made chemical perturbation, both theories recognizing certain unique features of the Antarctic region, such as atmospheric circulation patterns, extremely low temperatures, and polar stratospheric clouds.

The paucity of chemical data at the time for the Antarctic meant that it was difficult to decide which of these two theories, or a separate solar-cycle theory, was closer to the truth. Therefore, in the summer of 1986, NOAA joined with NSF, NASA, and CMA to rectify this data-short situation by helping organize, support, and participate in the National Ozone Expedition (NOZE). A NOAA scientist served as the team leader, and she and her colleagues helped make up a 20-investigator team that greatly added to the chemical information regarding the occurrence of the "ozone hole".

In addition, NOAA analysts have scrutinized the existing meteorological data for Antarctica to obtain a more detailed look at temperature trends and other physical parameters that might provide correlative clues regarding the mechanisms that could be responsible for the ozone decrease.

2. "Ozone Hole" Theories

Two general groups of theories, chemical and dynamical, have been proposed to explain the seasonal loss of ozone over Antarctica and its past increase in magnitude.

2.1 Chemical theories

The current chemical theories of the "ozone hole" fall into two classes, depending upon the identity of the chemical species hypothesized to be reacting with the ozone: man-made chlorine and bromine compounds and naturally occurring nitrogen compounds.

Man-made chlorine and bromine compounds

The fact that the seasonal Antarctic ozone loss began about the same time that stratospheric chlorine was increasing naturally led to man-made chlorine compounds being an early suspect. Besides, the ozone scientific community had been sensitized to halogens. However, while the chlorine-induced ozone-depletion theory does indeed predict that larger losses should occur at the high latitudes, the "ozone hole" is of a far greater magnitude than the few percent predicted for 1986 by the current global theory (c.f., Figures 4 and 9). In addition, no such ozone loss was occurring over the northern polar latitudes (Figure 7). The key parameter in a chlorine-induced ozone depletion is the fraction of stratospheric chlorine that is in a reactive form; the conventional global theory simply predicts too small a fraction to yield an ozone loss the size of the observed "ozone hole".

However, it was recognized that some of the unique physical conditions of the Antarctic stratosphere may cause a substantially higher fraction of reactive chlorine to exist there. Namely, the Antarctic stratosphere is the coldest of any region on the planet. Indeed, polar stratospheric clouds are present frequently in the Antarctic winter, much more so than in the Arctic. Laboratory studies have shown that the reactive form of chlorine can be liberated by chemical reactions that occur on surfaces, such as cloud particles.

Therefore, while there is a variety of differing details, the halogen theories of the "ozone hole" propose that the chemical reactions on the surfaces of polar stratospheric clouds "accelerate" the halogen-ozone chemistry compared to that elsewhere. The photochemical ozone loss is predicted to begin with the arrival of sunlight to the Antarctic region. With further warming, transport from ozone-richer northern latitudes later fills in the "hole". Since these theories tag man-made halogens as the cause of the ozone decrease, they predict that the "ozone hole" will deepen, on the average, with increasing stratospheric chlorine abundances.

Natural nitrogen compounds

It is well known that nitrogen compounds also catalytically deplete ozone. Indeed, such chemistry is part of the natural ozone balance in the stratosphere. Furthermore, it was the possible depletion of the ozone layer by enhanced reactive nitrogen compounds from the envisaged supersonic aircraft fleets that first brought the stratosphere to the attention of chemists in the early 1970's. Natural small-scale perturbations of the stratospheric nitrogen-ozone chemistry have been studied, confirming the chemical relations between reactive nitrogen compounds and ozone.

The ozone hole has been proposed to be the result of an unusually large and growing perturbation of the nitrogen chemistry over Antarctica. Specifically, it is suggested that large amounts of reactive nitrogen compounds were created in the highest parts of the atmosphere by the relatively intense solar activity occurring around 1980 and that these compounds were transported downwards to the upper stratosphere during the polar night. It was pointed out that such long-range and downward transport may be particularly effective for the cold, isolated Antarctic region. Hence, the arrival of sunlight in Antarctic spring would find a large abundance of reactive nitrogen compounds. A substantial photochemical loss of ozone in the upper stratosphere would commence, which would later be replenished, as noted above, by warming-induced mixing of ozone-rich air from more-northerly latitudes.

Therefore, while this theory employs chemistry, the chemicals are natural, and human influences are not implicated. Furthermore, since the driving force is periodic solar activity, this theory predicts that the currently occurring "ozone hole" is apt to diminish.

2.2 Dynamical Theories

As noted above, it is generally agreed that transport processes terminate the seasonal "ozone hole" phenomenon. However, a number of theories propose that dynamical processes may also explain its formation. Several such processes have been identified.

Because the Antarctic region gets exceedingly cold during the winter, the return of sunlight in the austral spring and the resultant warming may induce a net upward air motion, which would carry the ozone-poor air of the lower atmosphere (see Figure 1) into the lower stratosphere, which would yield a reduced column of ozone. The recent trend toward lower column ozone values is explained by possible increased heating associated with higher aerosol abundances arising from the recent volcanic eruptions (see Figure 8).

Larger-scale transport processes also have been proposed as causes of the lower ozone over Antarctica. In particular, the reduction of wintertime planetary wave activity in the southern hemisphere has been noted, which would lead to reduced downward transport of ozone into Antarctica during winter and spring. It was also noted that this would imply a colder region, which would enhance springtime upward air motions, and delay the final warmings. Similar transport processes have been proposed as being responsible for the larger-than-usual ozone levels just northward of the Antarctic region reported by satellites, i.e., a result of redistribution.

Therefore, the dynamical theories of the "ozone hole" recognize that large- and small-scale transport processes undergo natural variation on the scale of years to decades and propose that such "climatogical" changes can result in a gradual redistribution of ozone in the Southern Hemisphere, resulting in lower values in Antarctica. Such a cause is a natural ephemeral process that could well reverse in the future, leading to a return of the Antarctic ozone patterns of past decades.

- **Halogen-chemical, sunspot-induced-chemical, and dynamical/climate-change theories have been proposed as causes of the "ozone hole". The first evokes man-made perturbations; the latter two evoke natural processes.**

2.3 Chemical, Radiative, and Dynamical Couplings

As noted in Section II.B.3.3, there are well-known couplings between ozone, temperature, and circulation, e.g., absorption of radiation by ozone induces heating, temperature gradients cause air motion, and transport processes redistribute ozone. Thus, cause and effect are often difficult to separate. Nevertheless, correlations can be instructive in establishing the scope of the phenomenon.

The dynamical theories for the "ozone hole" generally imply that a cooling of 15 to 20°C should be associated with the long-term Antarctic ozone decrease if transport processes were responsible. However, if chemical processes were solely responsible for the phenomenon, the decrease in ozone, which is the principal heat source in the stratosphere, would also cause a cooling, albeit smaller. In addition, lower temperatures would imply more polar stratospheric clouds, which introduce another temperature-chemistry coupling. Hence, temperature trends have been sought in several Antarctic-ozone studies.

Unfortunately, the current results are not fully consistent. One investigation reported about 20°C changes, others claim that only 5-10°C changes have occurred. The data sets include those from both satellite measurements, as well as from balloon-borne radiosondes. The differences in these early analyses no doubt reflect, in part, the dearth of sounding sites in Antarctica, the understandable difficulty of making balloon soundings under those conditions, and the relatively short period of satellite observations.

- **The paucity of chemical and physical data at the time the theories of the "ozone hole" were proposed prevented the assessment of which one, ones, or if any were correct.**

3. 1986 Ground-based Chemical Observations

The National Ozone Expedition (NOZE) was at McMurdo Station, Antarctica, for the occurrence of the 1986 "ozone hole". Four teams focused a variety of ground-based apparatus and balloon-borne instruments on the chemical and aerosol characteristics of the phenomenon. Their observations that are reported thus far are the following:

3.1 Ozone

The ozone hole is a strongly seasonal phenomenon. The NOZE expedition did a great deal to clarify the understanding of its seasonal nature. The expedition arrived in Antarctica in late August to find total ozone levels and vertical profiles that were rather normal for that latitude and time of year. In the next several weeks, they witnessed about a 35% decrease of the total ozone overhead. Therefore, in addition to the strong evidence provided by the historical data extending back to the 1960's and 1950's showing a recent downward trend in Antarctic ozone, the behavior observed in a single spring season showed the growth of the hole very clearly.

Observations were made of the ozone abundance with two independent ground-based techniques, as well as from balloons. The excellent agreement of these data and the different principles involved in each measurement confirm that the change cannot be due to instrumental artifacts (such as volcanic or other natural contaminants).

In addition to confirming the decrease in column ozone, the balloon-borne measurements also revealed the changes that occurred in the vertical distribution of ozone. These data demonstrated that the ozone decrease occurred primarily in the lower stratosphere, 12 to 22 km, often in sharply defined layers.

3.2 Nitrogen Compounds

Nitrogen dioxide was measured with two independent techniques. The observed abundances of nitrogen dioxide were only about one third as large as Arctic observations or that predicted by "standard" global atmospheric theoretical models discussed in Section II.B above. The nitrogen dioxide abundances also did not change with time of day as would be expected and as has been observed at other latitudes. These observations demonstrate that the nitrogen photochemistry of the Antarctic stratosphere is anomalous.

3.3 Chlorine Compounds

Chlorine monoxide is closely tied to the possible depletion of Antarctic ozone due to halocarbons. The abundance of chlorine monoxide was established near 20 km. These data suggested that this compound was present in the Antarctic stratosphere in larger quantities than observed elsewhere. A related molecule is chlorine dioxide. This molecule was measured and found to be present at extremely high levels. The observed amount of chlorine dioxide was about 20-50 times greater than that occurring elsewhere or predicted by the "standard" global models, clearly demonstrating that the chlorine chemistry in the Antarctic stratosphere is also perturbed.

3.4 Implications

The observed chlorine and nitrogen perturbations are roughly consistent with the theory that the "ozone hole" is due to the chlorinated and brominated compounds. However, the uncertainties in the abundance of other chlorine and bromine species and in the chemical reactions that link the observed chlorine species to ozone depletions preclude, at present, treating the observations as proof of the halogenated chemical theory. The low nitrogen abundance and the occurrence of the ozone loss in the lower, rather than upper, stratosphere does make the solar-cycle theory more difficult to accept. The long-term record of meteorological variables continues to suggest a role of dynamical processes in the "ozone hole". Thus, while the role of the chlorinated and brominated compounds seems now somewhat more likely and that of the solar cycle seems less likely, the detailed cause of the "ozone hole" has not yet been established with certainty. Until the cause is better established, the question as to the significance to global ozone cannot be answered.

- **Measurements made on the 1986 National Ozone Expedition to Antarctica revealed that the abundance of the reactive chlorine compounds is highly elevated compared to other regions of the globe. Remaining uncertainties, however, prevent unequivocal identification of CFC's as the cause of the "ozone hole". Until the cause is established, the implications of the Antarctic ozone losses for global ozone are not known.**

- **Because the current theories of the cause of the "ozone hole" require the unique physical features of the region, the failure of the "standard" global ozone-depletion theories to predict its occurrence does not necessarily imply that these theories have major shortcomings regarding their predictions in other regions.**

4. NOAA Future Research

The fact that the chlorine chemistry in the Antarctic stratosphere is now known to be highly perturbed and the continuing need to define the dynamical processes make it mandatory to understand their roles in the "ozone hole" in much more detail. Hence, NOAA plans a greatly expanded effort during 1987. First, the agency's scientists will take an improved instrument back to NSF's

McMurdo Base. As in 1986, one of these NOAA scientists will be the leader of the expedition. Others will provide year-round ozonesonde balloon launches from the South Pole during 1987. In addition, NOAA will join NASA, NSF, CMA, and university investigators in an aircraft expedition to probe the chemistry and dynamics at the stratospheric altitudes where the ozone loss is occurring. NOAA scientists will have five chemical instruments on board NASA's ER-2 and DC-8 aircraft, and one of these investigators will serve as mission scientist. NOAA is also helping to provide satellite ozone data that will locate the "ozone hole" for flight planning and define its shape.

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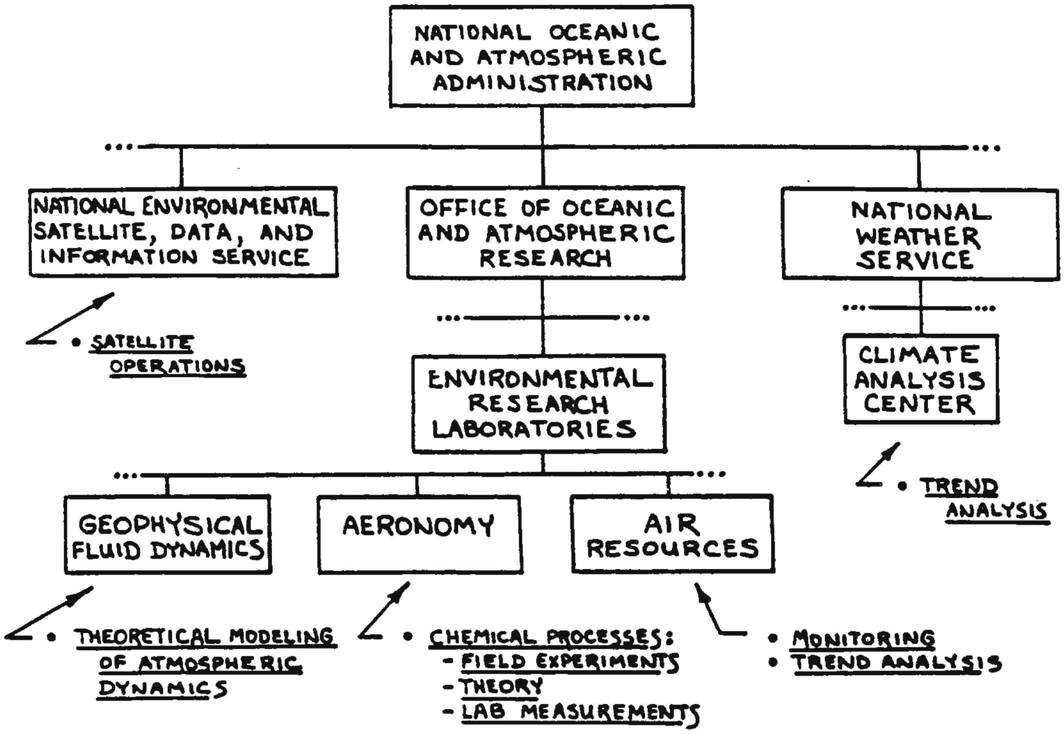
V. NOAA ORGANIZATIONAL UNITS ENGAGED IN STRATOSPHERIC OZONE RESEARCH



VI. AUTHORS

This summary was prepared by the following authors with the substantial help of numerous of their NOAA colleagues:

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VII. ACKNOWLEDGEMENTS

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EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, N. W.
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UNITED STATES VIEWS

on

REPORT OF THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT

The Report of the World Commission on Environment and Development, issued in London April 27, 1987, projects the alternative environmental and development prospects for mankind, in the broadest sense, into the next century. The challenges highlighted are among the major issues facing nations today.

The Commission and its Chairman, Prime Minister Gro Harlem Brundtland of Norway, are to be commended for proposing numerous creative strategies for addressing these global problems.

We note with special appreciation the major contribution made to this undertaking by the American member of the Commission, Mr. William D. Ruckelshaus, former Administrator of the U.S. Environmental Protection Agency, who served in an individual capacity and devoted substantial amounts of personal time and effort to this project over the course of the past three years. He deserves the sincere thanks of all Americans.

We share the Commission's overall view that the nations of the world, working cooperatively and energetically, should continue the growing effort to resolve the most urgent problems of producing needed goods and services while also safeguarding environmental quality. The Commission's deliberations have coincided with intensifying discussions of these important issues in the multilateral development banks, especially the World Bank, in the Organization for Economic Cooperation and Development (OECD), in the United Nations Environment Program (UNEP), and in other fora.

The report will be considered in June at the fourteenth session of the Governing Council of the United Nations Environment Program. We expect that the Governing Council will refer the Report to the UN General Assembly expeditiously so that it can be discussed in that forum this fall. The Commission was established as a result of a 1983 General Assembly resolution.

There are many elements in the report reflecting principles, positions and actions which the United States has embraced and to which it adheres. Examples include the central theme of Sustainable Development which will preserve and enhance environmental quality in the long term; the emphasis on economic growth, especially in less-developed nations, as a means of enhancing the environment, by attacking poverty which is often at the root of environmental degradation; and the need to integrate environmental considerations into economic decisions at the local, national and international level.

In many of the areas covered in the report, the United States is the recognized world leader in international efforts. For example, the U.S. is leading efforts to address the depletion of stratospheric ozone, after having unilaterally introduced a ban on CFC-containing aerosols. The U.S. also has a massive and expensive effort underway in developing a data base on atmospheric concerns. United States pioneering efforts should as well be noted with regard to development of the FAO code, the UNEP/OECD exchange and of being the first to implement a hazardous materials notification system. The United States also is proud to be in the forefront in stimulating international cooperation aimed at making development agencies accountable for environmental impacts of their projects.

Other important aspects of the Commission's report include its emphasis on specific environmental conservation issues such as deforestation and desertification; the centrality of UNEP's role in international environmental matters; increased public involvement in decisionmaking; greater utilization of private voluntary organizations and industry talents and resources; the important role of new technologies in addressing environmental problems; and improved integration of environmental considerations into national and international decisionmaking, including projects of the multilateral development banks.

In a comprehensive survey of this dimension, it is not surprising that there are approaches and assertions with which the United States cannot agree. These include the notion of a linkage between decreases in defense spending and increases in development spending; suggestions for compulsory international dispute settlement; automatic funding of environmental organization programs; and the report's simplistic treatment of the complex problem of transfering technology while protecting proprietary rights.

We also disagree with some of the suggestions concerning nuclear energy, the Law of the Sea Convention, the Antarctic Treaty, and management of outer space. We are also concerned that while some of the recommendations recognize the advantages of depending on market solutions, others recommend interference in market solutions with little promise of superior outcome. We are disappointed that the report understated the achievements and future potential of existing international conservation and environmental protection organizations and mechanisms, while calling for new, and possible costly, entities and mechanisms.

At times the report presumes the existence of sufficient scientific information on which to reach definitive conclusions on topics such as acid deposition and global warming. In fact, much more analysis needs to be done in these areas, as well as many others, to assure we know what to expect from control measures before we commit large expenditures of resources. The priority requirement is for development of a fundamental data base understood by all.

The United States is convinced that transfer of resources is not a panacea for the Third World problems described in the report. Significant environmental problems emerged in the 1970s during a period of relative affluence and high capital inflows into developing countries. Resource mismanagement and environmental degradation occurred in countries at that time as a result of development which did not take account of environmental values, and not because of lack of transfers. Many current problems are the result of that circumstance, of misguided policies in the countries concerned, and not due to more general circumstances of the global economy.

The Commission has called on the UN General Assembly to transform this report into a UN Program of Action on Sustainable Development leading to an international conference. In view of the work already well underway in the UN system and in other fora, such a program and conference would appear to be duplicative. We note that many of the ideas the report discusses are under active consideration in a number of fora.

The United States applauds the report's recognition of the power of people to prevail -- to build a future more just, more secure and more prosperous. We agree that individual citizen initiative and involvement, and education, are the basic essential ingredients for success. In this endeavor we must keep in mind that economic development is essential for the betterment of mankind and that technology is the mainspring of economic growth. By a commitment to research and a quest for knowledge, it is possible that just as we are generally better off than our parents, following generations will inherit a better world -- so long as we don't allow ourselves to be frightened of new technologies and additional research into such things as biotechnology, new energy sources, new chemicals and new medical frontiers, and so long as we remember that it is unlikely that we will ever live in a completely risk-free world.

We must recall that human genius, freedom, and rewards for personal incentive offer the global society an opportunity. We will keep this in mind as we continue to grapple with the concerns raised in the report.

April 27, 1987

Ralph/Vicky
- any action required?
NR

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, N. W.
WASHINGTON, D. C. 20006

April 28, 1987

MEMORANDUM TO: NANCY RISQUE
Assistant to the President
and Cabinet Secretary

FROM: A. ALAN HILL AH.
Chairman

SUBJECT: WCED REPORT

The World Commission on Environment and Development (WCED) Report will be released here in Washington today following its release yesterday in London. Dr. Gro Harlem Brundtland, Prime Minister of Norway, served as Chairman of the WCED. Bill Ruckelshaus served as a member of the Commission. Bill will be speaking on this topic at a luncheon meeting in the Cannon House Office Building at noon. Dr. Brundtland will present the report at 2:00 p.m. I will receive it on behalf of the government.

Attached is a copy of the report and U.S. views on the report. These were developed by an interagency group (agency contacts on the attached list). Could you see that this material gets in the hands of the appropriate people on your side of the street?

Thanks.

Enclosures

cc: Marlin Fitzwater
Joe Rodota

WCED Report Reviewers

Name	Agency	Telephone #
A. Alan Hill	Council on Environmental Quality	395-5080
Robert Raclin	Department of Health & Human Services	245-3400
Pamela Smith	National Security Council	395-5650
Everson Hull	Department of Labor	523-9070
Darrell Williams	Council of Economic Advisers	395-3517
Kenneth Brown	Department of Commerce	377-3727
Richard Benedick	Department of State	647-2232
Richard Johnson	Office of Science & Technology Policy	395-4823
Eugene Bierly	National Science Foundation	357-9874
Fistzhugh Green	Environmental Protection Agency	382-4870
Ronald Hauber	Nuclear Regulatory Commission	492-7131
Jim Conrow	Department of the Treasury	466-8243
Dennis Naugle	Office of the Secretary of Defense	653-1273
Steve Galebach	Department of Justice	633-1273
Ted Harris	Department of Energy	586-4766
Norman Hartness	Office of Management and Budget	395-6840
Indur Goklany	Department of the Interior	343-2151
John Tierney	Arms Control Disarmament Agency	647-8137
John Rosso	Department of Housing & Urban Development	755-7149
Norman Cohen	Agency for International Development	647-9662
Thomas Laughlin	National Oceanic & Atmospheric Administration	377-8196

710
PURPOSE AND DISCLAIMER

711 PURPOSE

(TL: POL-36 2-25-85)
(State Only)

a. The purpose of this chapter is to facilitate the application of orderly and uniform measures and procedures for the negotiation, signature, publication, and registration of treaties and other international agreements of the United States. It is also designed to facilitate the maintenance of complete and accurate records on treaties and agreements and the publication of authoritative information regarding them.

b. The chapter is not a catalog of all the essential guidelines or information pertaining to the making and application of international agreements. It is limited to guidelines or information necessary for general guidance.

712 DISCLAIMER

This chapter is intended solely as a general outline of measures and procedures ordinarily followed which, it is recognized, cannot anticipate all circumstances or situations that may arise. Deviation or derogation from the provisions of this chapter will not invalidate actions taken by officers nor affect the validity of negotiations engaged in or of treaties or other agreements concluded.

713 through 719 (Unassigned)

720
NEGOTIATION AND SIGNATURE

720.1 Circular 175 Procedure

(TL: POL-36 3-1-65)

This subchapter is a codification of the substance of Department Circular No. 175, December 13, 1955, as amended, on the negotiation and signature of treaties and other international agreements. It may be referred to for convenience and continuity as the "Circular 175 Procedure."

720.2 General Objectives

The objectives are:

a. That the making of treaties and other international agreements for the United States is carried out within constitutional and other appropriate limits;

b. That the objectives to be sought in the negotiation of particular treaties and other international agreements are approved by the Secretary or an officer specifically authorized by him for that purpose;

c. That timely and appropriate consultation is had with congressional leaders and committees on treaties and other international agreements;

d. That where, in the opinion of the Secretary of State or a designee, the circumstances permit, the public be given an opportunity to comment on treaties and other international agreements;

e. That firm positions departing from authorized positions are not undertaken without the approval of the Legal Adviser and interested assistant secretaries or their deputies;

f. That the final texts developed are approved by the Legal Adviser and the interested assistant secretaries or their deputies and, when required, brought a reasonable time before signature to the attention of the Secretary or an officer specifically designated by the Secretary for that purpose;

g. That authorization to sign the final text is obtained and appropriate arrangements for signature are made; and

h. That there is compliance with the requirements of *1 U.S.C. 112b, as amended,* on the transmission of the texts of international agreements other than treaties to the Congress (section 724); the law on the publication of treaties and other international agreements (see section 725); and treaty provisions on registration (see section 750.3-3).

721 EXERCISE OF THE INTERNATIONAL AGREEMENT POWER

721.1 Determination of Type of Agreement

The following considerations will be taken into account along with other relevant factors in determining whether an international agreement shall be dealt with by the United States as a treaty to be brought into force with the advice and consent of the Senate or as an agreement to be brought into force on some other constitutional basis.

721.2 Constitutional Requirements

There are two procedures under the Constitution through which the United States becomes a party to international agreement. Those procedures and the constitutional parameters of each are:

a. Treaties

International agreements (regardless of their title, designation, or form) whose entry into force with respect to the United States takes place only after the Senate has given its advice and consent are "treaties." The President, with the advice and consent of two-thirds of the Senators present, may enter into an international agreement on any subject genuinely of concern in foreign relations, so long as the agreement does not contravene the United States Constitution; and

b. International Agreements Other Than Treaties

International agreements brought into force with respect to the United States on a constitutional basis other than with the advice and consent of the Senate are "international agreements other than treaties." (The term "executive agreement" is appropriately reserved for agreements made solely on the basis of the constitutional authority of the President.) There are three constitutional bases for international agreements other than treaties as set forth below. An international agreement may be concluded pursuant to one or more of these constitutional bases:

(1) Agreements Pursuant to Treaty

The President may conclude an international agreement pursuant to a treaty brought into force with the advice and consent of the Senate, the provisions of which constitute authorization for the agreement by the Executive without subsequent action by the Congress;

(2) Agreements Pursuant to Legislation

The President may conclude an international agreement on the basis of existing legislation or subject to legislation to be enacted by the Congress; and

(3) Agreements Pursuant to the Constitutional Authority of The President

The President may conclude an international agreement on any subject within his constitutional authority so long as the agreement is not inconsistent with legislation enacted by the Congress in the exercise of its constitutional authority. The constitutional sources of authority for the President to conclude international agreements include:

(a) The President's authority as Chief Executive to represent the nation in foreign affairs;

(b) The President's authority to receive ambassadors and other public ministers;

(c) The President's authority as "Commander-in-Chief"; and

(d) The President's authority to "take care that the laws be faithfully executed."

721.3 Considerations for Selecting Among Constitutionally Authorized Procedures

In determining a question as to the procedure which should be followed for any particular international agreement, due consideration is given to the following factors along with those in section 721.2:

a. The extent to which the agreement involves commitments or risks affecting the nation as a whole;

b. Whether the agreement is intended to affect State laws;

c. Whether the agreement can be given effect without the enactment of subsequent legislation by the Congress;

d. Past U.S. practice as to similar agreements;

e. The preference of the Congress as to a particular type of agreement;

f. The degree of formality desired for an agreement;

g. The proposed duration of the agreement, the need for prompt conclusion of an agreement, and the desirability of concluding a routine or short-term agreement; and

h. The general international practice as to similar agreements.

In determining whether any international agreement should be brought into force as a treaty or as an international agreement other than a treaty, the utmost care is to be exercised to avoid any invasion or compromise of the constitutional powers of the Senate, the Congress as a whole, or the President.

721.4 Questions as to Type of Agreement to be Used; Consultation with Congress

a. All legal memorandums accompanying Circular 175 requests (see section 722.3h) will discuss thoroughly the bases for the type of agreement recommended.

b. When there is any question whether an international agreement should be concluded as a treaty or as an international agreement other than a treaty, the matter is brought to the attention of the Legal Adviser of the Department. If the Legal Adviser considers the question to be a serious one that may warrant congressional consultation, a memorandum will be transmitted to the Assistant Secretary for Legislative and Intergovernmental Affairs and other officers concerned. Upon receiving their views on the subject, the Legal Adviser shall, if the matter has not been resolved, transmit a memorandum thereon to the Secretary for a decision. Every practicable effort will be made to identify such questions at the earliest possible date so that consultations may be completed in sufficient time to avoid last-minute consideration.

c. Consultations on such questions will be held with congressional leaders and committees as may be appropriate. Arrangements for such consultations shall be made by the Assistant Secretary for Legislative and Intergovernmental Affairs and shall be held with the assistance of the Office of the Legal Adviser and such other offices as may be determined. Nothing in this section shall be taken as derogating from the requirement of appropriate consultations with the Congress in accordance with section 723.1e in connection with the initiation of, and developments during negotiations for international agreements, particularly where the agreements are of special interest to the Congress.

722 ACTION REQUIRED IN NEGOTIATION AND/OR SIGNATURE OF TREATIES AND AGREEMENTS

722.1 Authorization Required to Undertake Negotiations

Negotiations of treaties, or other international agreements on matters of substance, or for their extension or revision, are not to be undertaken, nor any exploratory discussions undertaken with representatives of another government, until authorized in writing by the Secretary or an officer specifically authorized by the Secretary for that purpose. Notification of the termination of any treaty or other international agreement on matters of substance requires similar authorization.

722.2 Scope of Authorization

Approval of a request for authorization to negotiate a treaty or other international agreement does not constitute advance approval of the text nor authorization to agree upon a date for signature or to sign the treaty or agreement. Authorization to agree upon a given date for, and to proceed with, signature must be specifically requested in writing, as provided in section 722.3. This applies to treaties and other agreements to be signed abroad as well as those to be signed at Washington. Special instructions may be required, because of the special circumstances involved, for multilateral conventions or agreements to be signed at international conferences.

722.3 Request for Authorization to Negotiate and/or Sign Action Memorandum

a. A request for authorization to negotiate and/or sign a treaty or other international agreement takes the form of an action memorandum addressed to the Secretary *or other Principal to whom such authority has been delegated, as appropriate, and cleared with the Office of the Legal Adviser (including the Assistant Legal Adviser for Treaty Affairs),* the Office of the Assistant Secretary for Legislative and Intergovernmental Affairs, other appropriate bureaus, and any other agency (such as Defense, Commerce, etc.) which has primary responsibility or a substantial interest in the subject matter. It is submitted through the Executive Secretariat.

b. The action memorandum may request one of the following: (1) authority to negotiate, (2) authority to sign, or (3) authority to negotiate and sign. The request in each instance states that any substantive changes in the draft text will be cleared with the Office of the Legal Adviser and other specified regional and/or functional bureaus before definitive agreement is reached. Drafting offices should consult closely with the Office of the Legal Adviser to insure that all legal requirements are met.

c. The action memorandum indicates what arrangements are planned as to: (1) congressional consultation, and (2) opportunity for public comment on the treaty or agreement being negotiated, signed, or acceded to.

d. The action memorandum shall indicate: (1) whether a proposed treaty or agreement embodies a commitment to furnish funds, goods, or services beyond or in addition to those authorized in an approved budget, and if so, (2) arrangements planned or carried out concerning consultation with the Office of Management and Budget (OMB) for such commitment.

e. The Department will not authorize such commitments without confirmation that the relevant budget approved by the President requests or provides funds adequate to fulfill the proposed commitment or that the President has made a determination to seek the required funds.

f. Where it appears that there may be obstacles to the immediate public disclosure of the text upon its entry into force, the action memorandum shall include an explanation thereof (see sections 723.2 and 723.3).

g. An action memorandum dealing with an agreement that has a potential for adverse environmental impact should contain a statement indicating whether the agreement will significantly affect the quality of the human environment.

h. The action memorandum is accompanied by: (1) *the U.S. draft, if available, of any agreement or other instrument in-*

tended to be negotiated, or (2) the text of any agreement and related exchange of notes, agreed minutes or other document to be signed (with appropriate clearances, including the Assistant Legal Adviser for Treaty affairs), and (3) a memorandum of law prepared in the Office of the Legal Adviser.

i. These provisions shall apply whether a proposed international agreement is to be concluded in the name of the U.S. Government, or in the name of a particular agency of the U.S. Government. However, in the latter case, the action memorandum may be addressed to the interested Assistant Secretary or Secretaries of State, or their designees in writing, unless such official(s) judge that consultation with the Secretary, Deputy Secretary or an Under Secretary is necessary. (See 22 CFR 181.4.)

722.4 Separate Authorizations

When authorization is sought for a particular treaty or other agreement, either multilateral or bilateral, the action memorandum for this purpose outlines briefly and clearly the principal features of the proposed treaty or other agreement, indicates any special problems which may be encountered and, if possible, the contemplated solutions of those problems.

722.5 Blanket Authorizations

In general, blanket authorizations are appropriate only in those instances where, in carrying out or giving effect to provisions of law or policy decisions, a series of agreements of the same general type is contemplated; that is, a number of agreements to be negotiated according to a more or less standard formula (for example, Public Law 480 Agricultural Commodities Agreements; Educational Exchange Agreements; Investment Guaranty Agreements; Weather Station Agreements, etc.) or a number of treaties to be negotiated according to a more or less standard formula (for example, consular conventions, extradition treaties, etc.). Each request for blanket authorization shall specify the office or officers to whom the authority is to be delegated. *The basic precepts under section 722.3 and 722.4 apply equally to requests for blanket authorizations. The specific terms of any blanket authorization, e.g., that the text of any particular agreement shall be cleared by the Office of the Legal Adviser and other interests bureaus before signature, shall be observed in all cases.*

722.6 Certification of Foreign-Language Text

a. Before any treaty or other agreement containing a foreign-language text is laid before the Secretary (or any person authorized by the Secretary) for signature, either in the Department or at a post, a signed memorandum must be obtained from a responsible language officer of the Department certifying that the foreign-language text and the English-language text are in conformity with each other and that both texts have the same meaning in all substantive respects. A similar certification must be obtained for exchanges of notes that set forth the terms of an agreeement in two languages.

b. In exceptional circumstances the Department can authorize the certification to be made at a post.

722.7 Transmission of Texts to the Secretary

The texts of treaties and other international agreements must be completed and approved in writing by all responsible officers concerned sufficiently in advance to give the Secretary, or the person to whom authority to approve the text has been delegated, adequate time before the date of signing to examine the text and dispose of any questions that arise. Posts must transmit the texts to the Department as expeditiously as feasible to assure adequate time for such consideration. Except as otherwise specifically authorized by the Secretary, a complete text of a treaty or other international agreement must be delivered to the Secretary, or other person authorized to approve the text, before any such text is agreed upon as final or any date is agreed upon for its signature.

723 RESPONSIBILITY OF OFFICE OR OFFICER CONDUCTING NEGOTIATIONS

723.1 Conduct of Negotiations

The office of officer responsible for any negotiations keeps in mind:

a. That during the negotiations no position is communicated to a foreign government or to an international organization as a U.S. position that goes beyond any existing authorization or instructions;

b. That no proposal is made or position is agreed to beyond the original authorization without appropriate clearance (see section 722.3a);

c. That all significant policy-determining memorandums and instructions to the field on the subject of the negotiations have appropriate clearance (see section 722.3a);

d. That the Secretary *or other Principal, as appropriate,* is kept informed in writing of important policy decisions and developments, including any particularly significantly departures from substantially standard drafts that have been evolved;

e. That with the advice and assistance of the Assistant Secretary for Legislative and Intergovernmental Affairs, the appropriate congressional leaders and committees are advised of the intention to negotiate significant new international agreements, consulted concerning such agreements, and kept informed of developments affecting them, including especially whether any legislation is considered necessary or desirable for the implementation of the new treaty or agreement. Where the proposal for any especially important treaty or other international agreement is contemplated, the Office of the Assistant Secretary for Legislative and Intergovernmental Affairs will be informed as early as possible by the office responsible for the subjects;

f. That the interest of the public be taken into account and, where in the opinion of the Secretary of State or his designee the circumstances permit, the public be given an opportunity to comment;

g. That in no case, after accord has been reached on the substance and wording of the texts to be signed, do the negotiators sign an agreement or exchange notes constituting an agreement until a request under section 722.3 for authorization to sign has been approved and, if at a post abroad, until finally instructed by the Department to do so as stated in section 730.3. If an agreement is to be signed in two languages, each language text must be cleared in full with the Language Services Division or, if at a post abroad, with the Department before signature, as stated in section 722.6;

h. That due consideration is given also to the provisions of sections 723.2 through 723.9, 730.3 and 731 of this chapter; and

i. That, in any case where any other department or agency is to play a primary or significant role or has a major interest in negotiation of an international agreement, the appropriate official or officials in such department or agency are informed of the provisions of this subchapter.

723.2 Avoiding Obstacles to Publications and Registration

The necessity of avoiding any commitment incompatible with the law requiring publication (1 U.S.C. 112a) and with the treaty provisions requiring registration (see section 750.3-3) should be borned in mind by U.S. negotiators. Although negotiations may be conducted on a confidential basis, every practicable effort must be made to assure that any definitive agreement or commitment entered into will be devoid of any aspect which would prevent the publication and registration of the agreement.

723.3 Questions on Immediate Public Disclosure

In any instance where it appears to the officer or office in the Department responsible for the negotiations or to the U.S. representatives that the immedate public disclosure upon its entry into force of an agreement under negotiations would be prejudicial to the national security of the United States, the pertinent circumstances shall be reported to the Secretary of State and his decision awaited before any further action is taken. Where such circumstances are known before authorization to negotiate or to sign is requested, they shall be included in the request for authorization. All such reports and requests are to be cleared with the Office of the Legal Adviser.

723.4 Public Statements

No public statement is to be made indicating that agreement on a text has been reached, or that negotiations have been successfully completed, before authorization is granted to sign the treaty or other agreement. If such authorization has been granted subject to a condition that no substantive change in the proposed text is made without appropriate clearance (see section 722.3a), no such public statement is to be made until definitive agreement on the text has been reached and such clearance has been received. Normally, such a public statement is made only at the time a treaty or other agreement is actually signed, inasmuch as it remains possible that last-minute changes will be made in the text. Any such statement prior to that time must have the appropriate clearance, and the approval of the Secretary or the Department principal who originally approved the action memorandum request under "Circular 175 Procedure."

723.5 English-Language Text

Negotiators will assure that every bilateral treaty or other international agreement to be signed for the United States contains an English-language text. If the language of the other country concerned is one other than English, the text is done in English and, if desired by the other country, in the language of that country. A U.S. note that constitutes part of an international agreement effected by exchange of notes is always in the English language. If it quotes a foreign *government* note, the quotation is to be rendered in English translation. A U.S. note is not in any language in addition to English, unless specifically authorized *(with the clearance of the Assistant Legal Adviser for Treaty Affairs).* The note of the other government concerned may be in whatever language that government desires.

723.6 Transmission of Signed Texts to Assistant Legal Adviser for Treaty Affairs

a. The officer responsible for the negotiation of a treaty or other agreement at any post is responsible for insuring the most expeditious transmission of the signed original text, together with all accompanying papers such as agreed minutes, exchanges of notes, plans, etc. *(indicating full names of persons who signed),* to the Department for the attention of the Assistant Legal Adviser for Treaty Affairs; *Provided,* that where originals are *not* available accurate certified copies are obtained and transmitted as in the case of the original. (See sections 723.7, 723.8, and 723.9.) The transmittal is by airgram, *not* by transmittal slip or operations memorandum.

b. Any officer in the Department having possession of or receiving from any source a signed original or certified copy of a treaty or agreement or of a note or other document constituting a part of a treaty or agreement must forward such documents immediately to the Assistant Legal Adviser for Treaty Affairs.

723.7 Transmission of Certified Copies to the Department

When an exchange of diplomatic notes between the mission and a foreign government constitutes an agreement or has the effect of extending, modifying, or terminating an agreement to which the United States is a party, a properly certified copy of the note from the mission to the foreign government, and the signed original of the note from the foreign government are sent, as soon as praticable *(indicating full names of persons who signed)* to the Department for attention of the Assistant Legal Adviser for the Treaty Affairs. The transmittal is by airgram, *not* by transmittal slip or operations memorandum.

Likewise, if, in addition to the treaty or other agreement signed, notes related thereto are exchanged (either at the same time, beforehand, or thereafter), a properly certified copy (copies) of the note(s) from the mission to the foreign government are transmitted with the signed original(s) of the note(s) from the foreign government.

In each instance, the mission retains for its files certified copies of the note exchanged. The U.S. note is prepared in accordance with the rules prescribed in the *Correspondence Handbook.* The note of the foreign government is prepared in accordance with the style of the foreign ministry and usually in the language of that country. Whenever practicable, arrangements are made for the notes to bear the same date.

723.8 Certification of Copies

If a copy of a note is a part of an international agreement, such copy is certified by a duly commissioned and qualified Foreign Service Officer either (a) by a certification on the document itself, or (b) by a separate certification attached to the document. A certification on the document itself is placed at the end of the document. It indicates, either typed or rubber stamped, that the document is a true copy of the original signed (or initialed) by *(INSERT FULL NAME OF OFFICER WHO SIGNED DOCUMENT),* and it is signed by the certifying officer. If a certification is typed on a separate sheet of paper, it briefly describes the document certified and states that it is a true copy of the original signed (or initialed) by *(FULL NAME)* *and it is signed and dated* by the certifying officer. The certification may be stapled to the copy of the note.

723.9 Preparation of Copies for Certification

For purposes of accuracy of the Department's records and publication and registration, a certified copy must be an exact copy of the signed original. It must be made either by typewriter (ribbon or carbon copy) or by facsimile reproduction on white durable paper (not by the duplimat method) and must be *CLEARLY LEGIBLE*. In the case of notes, the copy shows the letterhead, the date and, if signed, an indication of the signature or, if merely initialed, the initials which appear on the original. It is suggested that, in the case of a note from the mission to the foreign government, the copy for certification and transmission to the Department be made at the same time the original is prepared. If the copy is made at the same time, the certificate prescribed in section 723.8 may state that the document is a true and correct copy of the signed original. If it is not possible to make a copy at the same time the original is prepared, the certificate indicates that the document is a true and correct copy of the copy on file in the mission. The word "(Copy)" is not placed on the document which is being certified; the word "(Signed)" is not placed before the indication of signatures. Moreover, a reference to the transmitting airgram, such as "Enclosure 1 to Airgram No. 18 (ect.)", is not placed on the certified document. The identification of such a document as an enclosure to an airgram may be typed on a separate slip of paper and attached to the document, but in such a manner that it may be easily removed without defacing the document.

724 TRANSMISSION OF INTERNATIONAL AGREEMENTS OTHER THAN TREATIES TO CONGRESS: COMPLIANCE WITH THE *CASE-ZABLOCKI ACT*

All officers will be especially diligent in cooperating to assure compliance with Public Law 92-403 "An Act to require that international agreements other than treaties, hereafter entered into by the United States, be transmitted to the Congress within sixty days after the execution thereof. "That Act, *popularly known as the Case-Zeblocki Act*, approved August 22, 1972 (86 Stat. 619; 1 U.S.C. 112b), provides as follows:

> The Secretary of State shall transmit to the Congress the text of any international agreement other than a treaty, to which the United States is a party as soon as practicable after such agreement has entered into force with respect to the United States but in no event later than sixty days thereafter. However, any such agreement the immediate public disclosure of which would in the opinion of the President, be prejudicial to the national security of the United States shall not be so transmitted to the Congress but shall be transmitted to the Committee on Foreign Relations of the Senate and the Committee on Foreign Affairs of the House of Representatives under an appropriate injunction of secrecy to be removed only upon due notice from the President.

725 PUBLICATION OF TREATIES AND OTHER INTERNATIONAL AGREEMENTS OF THE UNITED STATES

The attention of all officers is directed to the requirements of the Act of September 23, 1950 (64 Stat. 979; 1 U.S.C. 112a), which provides as follows:

> The Secretary of State shall cause to be compiled, edited, indexed, and published, beginning as of January 1, 1950, a compilation entitled "United States Treaties and Other International Agreements," which shall contain all treaties to which the United States is a party that have been proclaimed during each calendar year, and all international agreements other than treaties to which the United States is a party that have been signed, proclaimed, or with reference to which any other final formality has been executed, during each calendar year. The said United States Treaties and Other International Agreements shall be legal evidence of the treaties, international agreements other than treaties, and proclamations by the President of such treaties and agreements, therein contained, in all the courts of the United States, the several States, and the Territories and insular possessions of the United States.

726 through 729 (Unassigned)