Abstract

NOAA/ESRL GLOBAL MONITORING DIVISION – EARLY HISTORY

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The mission of the NOAA Earth System Research Laboratory (ESRL)-Global Monitoring Division (GMD), formed in 2005, is "to observe and understand through accurate long-term records of atmospheric gases, aerosol particles, and solar radiation, the Earth's atmospheric systems that control climate forcing, ozone depletion, and baseline air quality, for the purpose of developing products that will advance global and regional environmental information and services." Predecessors of ESRL-GMD were: the U.S. Department of Commerce Weather Bureau, Special Projects Section (WB/SPS) 1956-1965; Environmental Science Services Administration (ESSA), Air Resources Laboratory (ARL) 1965-1966; ESSA, Atmospheric Physics and Chemistry Laboratory, 1966-1970; NOAA Air Resources Laboratory, Geophysical Monitoring for Climatic Change (GMCC) Division, 1970-1990; and the NOAA Climate Monitoring and Diagnostics Laboratory (CMDL) 1990-2005. The roots and legacy of ESRL-GMD date back to the 1957-1958 International Geophysical Year (IGY). The goal of the 1957-1958 IGY, overseen by the International Council of Scientific Unions (ICSU), was to encourage scientists from around the world to take part in a series of coordinated observations of various geophysical phenomena. During IGY 1957-1958, the U.S. Weather Bureau Special Products Section began monitoring carbon dioxide and total ozone at Mauna Loa Observatory in Hawaii, South Pole, Antarctica, and at a network of Dobson ozone spectrophotometer total ozone measurement stations on the U.S. mainland. These observations continue to this day, and comprise sets of data that have already played an important role in mitigating harmful effects of pollutants such as the halocarbons and carbon dioxide. This report, prepared at the time of IGY 2007-2009, commemorates the global geophysical measurements made 50 years ago during IGY 1957-1958, and celebrates the 50th anniversary of the Mauna Loa and South Pole carbon dioxide and total ozone records, as well as the U.S. mainland stations' total ozone data, that are incorporated into the ESRL-GMD data archives. It, furthermore, describes the activities and events of the Weather Bureau Special Projects Section and of the ESSA/NOAA Air Resources Laboratory that culminated in formation in 1970 of the NOAA Air Resources Laboratory, Geophysical Monitoring for Climatic Change (GMCC) Division.

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The seed for the NOAA/ESRL-Global Monitoring Division was sown in France in the early 1930's when two French scientists, Fabry and Buisson, developed the first single-monochrometer ozone spectrometer. Their ground-based measurements revealed for the first time the basic characteristics of the earth's ozone layer located above the atmosphere's tropopause. Soon came the realization that the ozone layer shielded the earth's surface from harmful solar ultraviolet radiation, thereby making life on earth possible; and that the ozone layer, furthermore, due to its propensity to warm through absorption of solar radiation was in fact a precursor of the tropopause and, hence, played a pivotal role in the earth's weather and climate.

In the mid 1930s, G.M.B. Dobson of Oxford, England, following the work of Fabry and Buisson, designed and built a double monochrometer UV Dobson ozone spectrophotometer having such superb characteristics of long-term stability, sensitivity, precision, and accuracy that more than 100 of such instruments are in use throughout the world to this day. Instructions were issued to users of Dobson spectrophotometers for conduction of routine, monthly spectral and standard lamp tests to insure integrity of the observations being made. Dobson, furthermore, described in detail the technique for calibrating Dobson spectrophotometers on an absolute scale. The method involves analysis of total ozone data obtained from observations on the rising or setting sun during 20-30 clear, pollution-free one-half days when overhead ozone remains relatively constant.

In 1956, I was a graduate student working in spectroscopy at the University of Alberta, Canada, where there happened to be a Dobson ozone spectrophotometer. Becoming familiar with the instrument, I realized that it was likely not very well calibrated on an absolute scale because all initial Dobson instrument calibrations were performed in the highly polluted atmosphere of Oxford, England where the instruments were manufactured. The year 1956 was, also, the year before the 1957-1958 International Geophysical Year. This was, also, the year when I was looking for a job.

I decided to take a job offered by the Canadian Department of Transport which had established a new Dobson spectrophotometer observatory at Moosonee, Ontario, Canada, situated on the shore of James Bay which is an extension of Hudson Bay. This presented me with a unique opportunity to calibrate my Dobson spectrophotometer No. 62 on an absolute calibration scale from ozone observations made in pristine Canadian air, and to obtain a total ozone data set during the 1957-1958 IGY of base-line data quality (Figure 1). (These data are worthwhile incorporating into the NOAA GSRL-GMD data archive). Following the work at Moosonee, I continued my employment by the Canadian Department of Transport near Toronto, Ontario, where I had an opportunity to train Archie Asbridge of the Canadian Meteorological Service in the optical alignment, optical adjustment, calibration, operation, and maintenance of Dobson ozone spectrophotometers. Within a couple of years, Asbridge re-vamped the Canadian Dobson instrument network to become (and continues to be) among the finest of such station networks in the world.

In 1961 I received an invitation from Dr. Lester Machta of the U.S. Weather Bureau's Special Project's Section (SPS) in Washington, D.C., to head the Section's Dobson spectrophotometer ozone observations program. At that time the U.S. Dobson instrument network consisted of six stations on the U.S. mainland and two in Antarctica. All instruments were in need of improved absolute calibrations, as well as a rigid operating protocol whereby the calibration stability of all instruments would be checked at monthly intervals by means of spectral and standard lamp tests. Some of the network Dobson instruments had been purchased by the Weather Bureau's Special Projects Section for use during the 1957-1958 International Geophysical year. During 1957, also, Dr. Machta began supporting the work of Dr. C.D. Keeling of the Scripps Institute of Oceanography in establishing clean-air CO_2 observatories on Mauna Loa and at South Pole, Antarctica. The support was in the form of a meteorological assistant, Eugene Wilkens, and an observatory facility on Mauna Loa. (In 1959, Thomas B. Harris assumed the duties of Eugene Wilkens at Scripps). Dr. Machta was an environmentally conscientious meteorologist (and a superb boss to work for) among whose many tasks at the Weather Bureau in those years was involvement in meteorological network operations that tracked radio-active fall-out that vented from underground nuclear test explosions conducted in Nevada.

I accepted the 1961 job offer from the U.S. Weather Bureau Special Projects Section. Work began with establishment of a Primary Standard Dobson Ozone Spectrophotometer No. 83 at Sterling, Virginia located 30 miles west of Washington, D.C., for use in calibrating all other instruments in the U.S. Dobson instrument network. This was followed by visitations to the various stations (with instrument 83) to assess the calibration status of the station instruments, to upgrade the instruments optically and electronically, and to assign absolute calibrations to the instruments through comparison ozone observations with Primary Standard Dobson Instrument No. 83. In 1964, Robert D. Grass, who had been

the South Pole, Antarctica, ozone observer in 1963, joined the Weather Bureau to assist with the work. In 1963, also, Thomas Harris was redeployed from Scripps to the Sterling, Virginia, laboratory where, among a number of duties, he assisted me in the development and testing of the Electrochemical Concentration (ECC) ozonesonde which is the instrument of choice by researchers throughout the world for measurements of the vertical distribution of ozone.

In 1965, the U.S. Department of Commerce began partial re-organization, with creation within a new U.S. Environmental Science Services Administration (ESSA) an Air Resources Laboratory (ARL) which would continue the former duties of the WB Special Projects Section. At about the same time, a new laboratory was being created in Boulder, Colorado, named the Atmospheric Physics and Chemistry Laboratory (APCL) headed by Dr. Helmut Weickmann, formerly from the Air Force Cambridge Research Laboratory in Bedford, Massachusetts. I was given the option of joining ESSA or moving the Dobson Spectrophotometer program, with Robert Grass and Thomas Harris, to Boulder, Colorado. I elected to move to Boulder, which I did in July of 1966.

By the time of the move to Boulder, much of the work of upgrading the (now APCL) total ozone monitoring program was accomplished. Work was begun on applying corrections where needed to earlier ozone data since the early 1960's (Figure 2). Robert Grass was ably running the routine ozone program network operations and processing the station data. And I had time on my hands to ponder the future of APCL research.

Dr. Weickmann's primary interests centered on advertent weather modification research involving cloud seeding, hail suppression, lightning suppression, and the affects of aerosols on cloud formation. My own concern for many years had been inadvertent weather and climate modification. So in September of 1967 I wrote a short paper proposing the establishment by the ESSA Atmospheric Physics and Chemistry Laboratory of several remote clean-air observatories at strategic locations in the world for monitoring radiationally active atmospheric trace gases, ever increasing man-made pollutants, and the afluents of episodic volcanic eruptions and dust storms that have a potential of changing weather and climate and, thereby, adversely affecting the plant, animal and human life on earth. Dr. Weickmann read the proposal, thought it was O.K., but expressed concern as to who might lead such a project. Fortunately, a meeting was scheduled to be held the following month in Washington, D.C., by the National Academy of Sciences Advisory Committee to ESSA on the subject of weather modification. Dr. Weickmann was scheduled to present a paper at the meeting. He agreed to schedule me on the meeting roster for presentation of my paper entitled "Inadvertent Modification of the Atmosphere."

I presented my paper (Appendix A) before the National Academy of Sciences Advisory Panel members on November 9, 1967. A lively discussion followed. All agreed that the baseline station proposal as described would be a worthwhile scientific endeavor. Upon returning to Boulder, I received several telephone calls from enthusiastic researchers about the proposed project, as well as some media attention. But then nothing happened for months.

In late summer of 1968 I decided to take a year's sabbatical leave from APCL to advance my knowledge in meteorology, fluid mechanics, computer science and quantum mechanics. Towards the

end of the second semester in the spring of 1969 I received a surprising telephone call from my former boss in Washington, D.C., Dr. Lester Machta of the Air Resources Laboratory, inviting me to rejoin his Laboratory to help implement the clean air baseline station network that I had talked about at the 1967 National Academy of Science meeting. I accepted immediately. Implementing the program in late 1969, Dr. Machta established a branch of the Air Resources in Boulder, naming it the Geophysical Monitoring for Climate Change (GMCC) Laboratory. Donald Pack, a colleague of his in Washington, D.C. was named the new Laboratory's Administrative Director, and the title of Chief, Techniques and Standards Group, was bestowed upon me.

Robert Grass continued routine operation of the now Air Resources Laboratory GMCC total ozone measurements program in Boulder, while Thomas Harris assumed responsibility for the GMCC CO_2 measurements program. South Pole Observatory in Antarctica and Mauna Loa Observatory in Hawaii were soon selected as the first two GMCC Laboratory baseline observatories. A search began for additional such observatories. Thomas Harris was deployed to several sites in the world with a flask air sample collection kit and an Aitken nuclei counter for use in assessing the air cleanliness at the sites. Analyses of the air samples for CO_2 content were performed using a non-dispersive infrared Applied Physics Company analyzer apparatus built for GMCC by Walter Bischof of the University of Stockholm, Sweden. Ultimately, two new baseline stations were selected: Tutuila Island, American Samoa in the South Pacific, and Point Barrow in Alaska.

Among the first new programs conducted in Boulder following formation of GMCC was the revamping of Dobson ozone spectrophotometers of the global instrument network that had not yet been calibrated relative to Primary Standard Dobson Instrument 83. Beginning in 1970, foreign Dobson instruments were brought to Boulder, under auspices of the World Meteorological Organization (WMO), for upgrading and calibrating with instrument 83, named later by the WMO as the Primary Dobson Ozone Spectrophotometer for the World. Alternatively, periodic Dobson Instrument Intercomparisons were sponsored by the WMO in foreign countries where regional Dobson spectrophotometers were brought together for calibrations with instrument 83. By the early 1980's most instruments of the global Dobson instrument network had calibrations traceable to Primary Standard Dobson Instrument 83. The value of the Dobson instrument calibrations program was underscored in 1984 when analyses of NASA TOMS satellite total ozone data indicated a disturbingly high rate of atmospheric ozone depletion, a matter of considerable consternation. Analyses of total ozone trends from the U.S. Dobson stations' data and from re-evaluated data of a number of foreign countries where Dobson's instruments had been calibrated relative to Standard 83 (Figure 3), however, indicated a much smaller ozone depletion rate. After considerable investigation of the difference in results, it was reported in a Report of the International Ozone Trends Panel 1988, Volume 1, that the conclusions drawn by the Trends Panel **"... are strongly based on the provisionally revised ground-based data, and these in turn are traceable to the calibration record for instrument No. 83. The TOMS satellite data have all been normalized to the Dobson networks, and therefore to the calibration record of instrument No. 83."**

As time passed, under guidance of Dr. Lester Machta, Director of the NOAA Air Resources Laboratory, the Geophysical Monitoring for Climatic Change (GMCC) program that began in Boulder, Colorado, in 1970 with a handful of scientists and two baseline observatories, grew (Figure 4) by 1989 to

four primary observatories, many secondary monitoring sites scattered over the globe, nearly 100 staff, and a budget of $5 million per year. Dr. Machta retired in 1989. In early 1990, The NOAA Air Resources Laboratory, GMCC Division became the NOAA Climate Monitoring and Diagnostics Laboratory.

Observing programs at GMCC and at the successor Climate Monitoring and Diagnostics Laboratory and the current Earth System Research Laboratory are unique and of inestimable value in their goal to monitor on a long-term basis atmospheric trace gases, man-made pollutants as well as select natural geophysical parameters that affect human welfare and climate. Measured data obtained at the baseline and associated observatories, together with relevant research, have already played a role in mitigating harmful effects of pollutants such as fluorocarbons and CO_2, and will continue to do so as increasing human population concomitant with enhanced industrial pollution adversely affect climate, plant, animal and human life on earth.

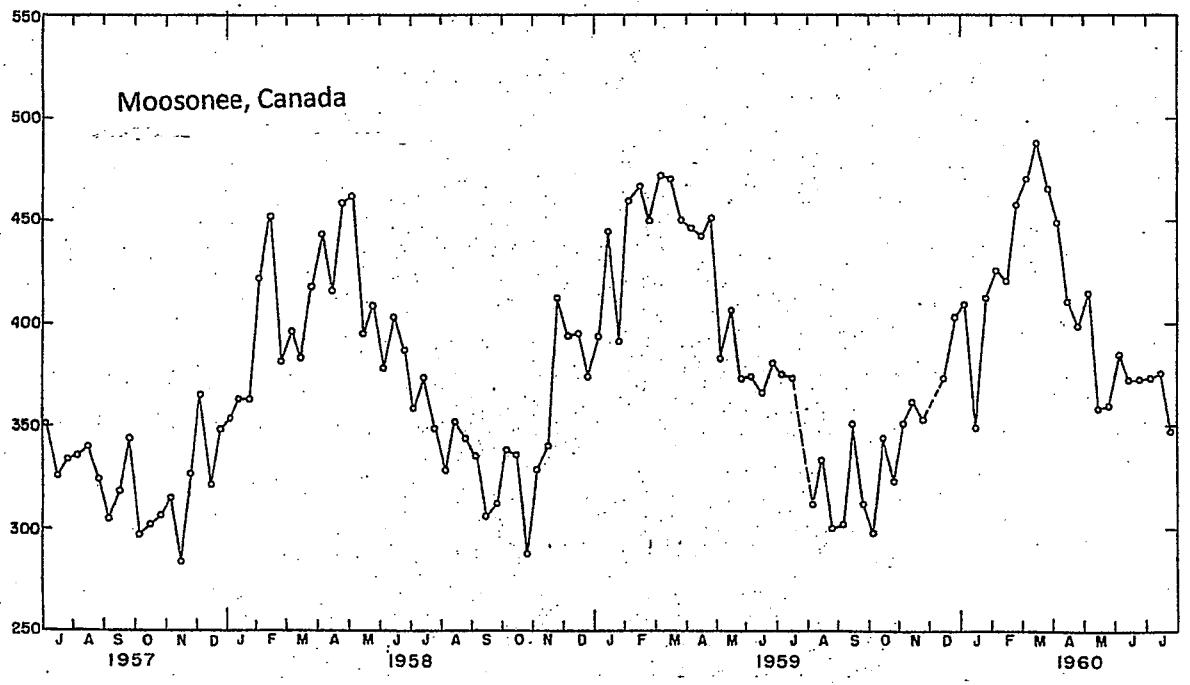

Figure 1. Decadic Means of Total Ozone (D.U.) July 1957 to July 1960

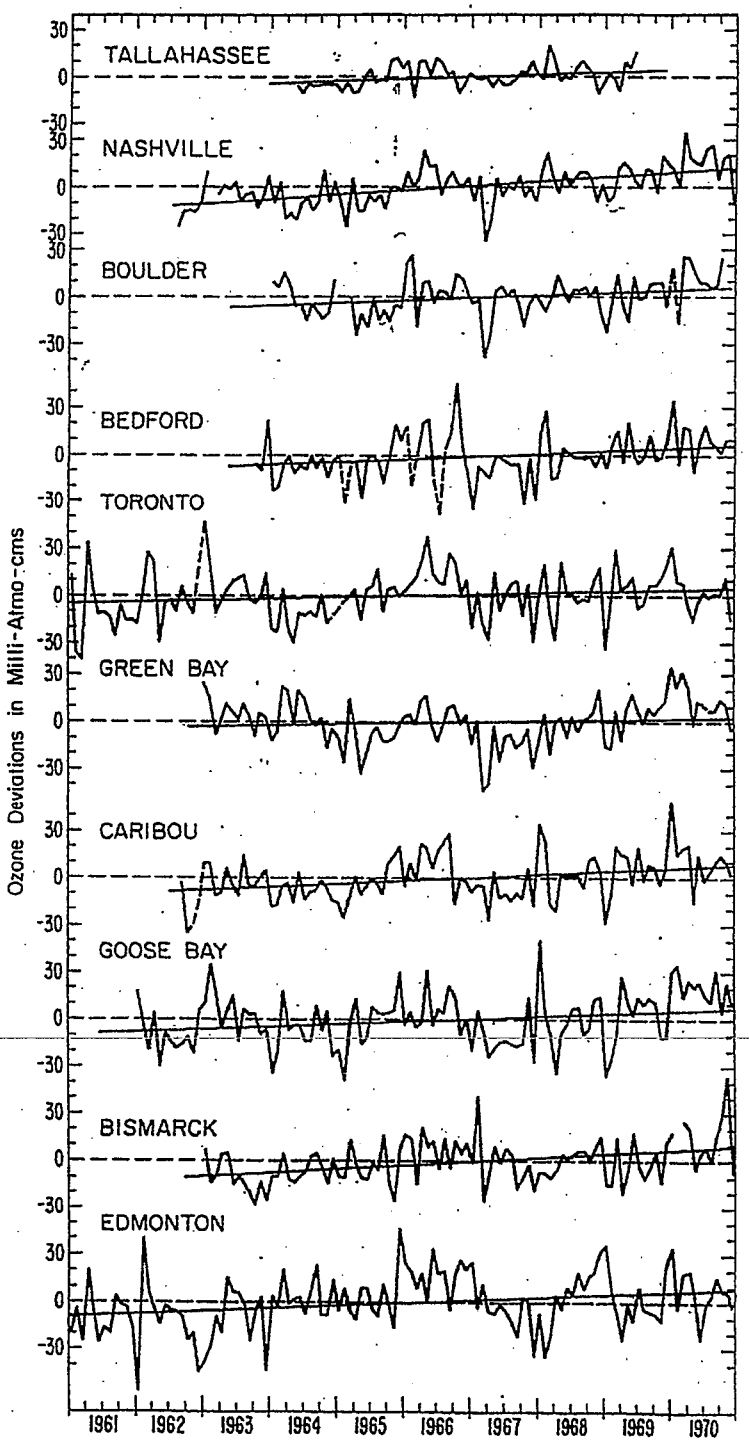

Figure 2. Plots of mean monthly total ozone deviations from monthly normals for North American stations. Linear trends are fitted to the data.

Figure 3

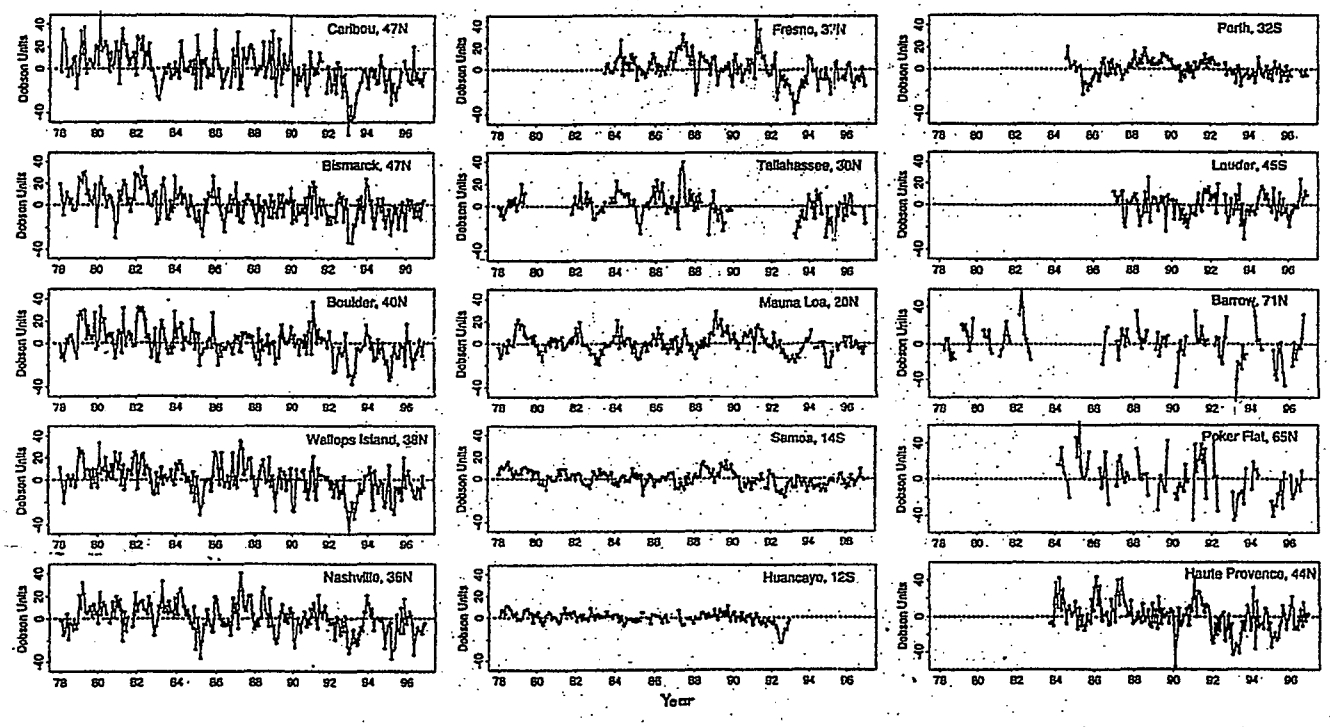

Figure 1. Deseasonalized total ozone anomaly data for 15 NOAA/CMDL and cooperative stations formed by subtracting 1979-1996 monthly normals from total ozone monthly means for the indicated periods of record. Observations at Point Barrow and Poker Flat were made only during the months of February to October of each year.

the annual ozone trend at Fresno of -3.7%/decade approximates the five-station average annual trend for 1979-1996 of -3.3%/decade, a difference is evident in the seasonal dependence of the trends. At Tallahassee, ozone trends derived from the episodic data approximate those at Fresno–a result that may be in part fortuitous, but may also reflect a real difference in the regional pattern of the trends.

Annual downward trends in ozone during 1979-1996 at the lower latitude Mauna Loa and Samoa Observatories were smaller, viz., -0.4 ± 0.7 and -1.3 ± 0.6%/decade, respectively, being not significant at Mauna Loa and barely significant at Samoa at the 95% confidence interval level. The annual trend derived from the shorter 1979-1992 Huancayo Observatory record was more negative (-1.9 ± 0.4%/decade). This result is biased, however, by the pronounced ozone low that occurred at Huancayo during the 1992 austral winter (Figure 1). Excluding the end-of-record 1992 data, the 1979-1991 annual ozone trend for Huancayo was determined to be -0.9 ± 0.4%/decade.

NOAA cooperative total ozone observations began at Perth and Lauder in the Southern Hemisphere, respectively, in 1984 and 1987. Through 1996, both of these shorter-record stations show maximum downward trends in ozone of about -3.0 ± 1.0%/decade occurring during austral summer months. On an annual basis, ozone trends at both stations were about 1.0%/decade, though not statistically significant and of opposite sign. Positive, not statistically significant trends occurred also during austral winter at Perth and during austral spring at Lauder. The large, positive, statistically significant wintertime trend of 5.0 ± 2.3%/decade deduced for Lauder is, most likely, a reflection of the shortness (10 years) of the Lauder record and the anomalously high ozone values (not shown) present in the Lauder region during July months of 1994-1996, and August months of 1994 and 1996.

Observations at the high-latitude North American stations of Poker Flat and Point Barrow were not made during winter months, nor at Point Barrow during 1983-1986. However, sufficient

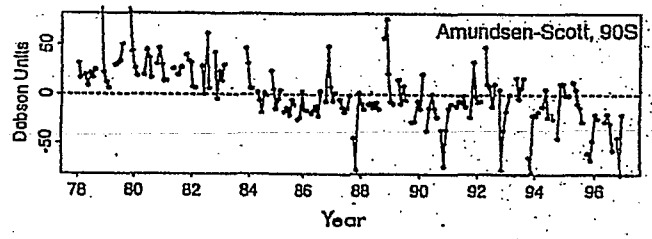

Figure 2. South Pole station monthly total ozone anomalies derived from austral daylight observations made during October to February months.

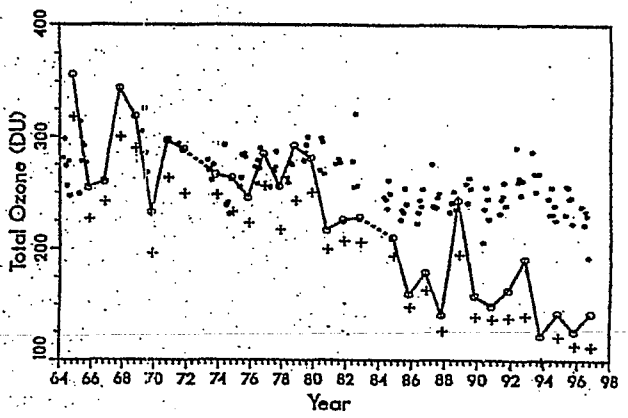

Figure 3. South Pole station October 15-31 total ozone "monthly" means for 1964-1996 (circles). Crosses indicate October ozone minimum values. The dots plot wintertime (March-August) total ozone amounts.

Figure 4

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APPENDIX A

Inadvertent Modification of the Atmosphere

Walter D. Komhyr

Paper presented at a Meeting of the National Academy of Sciences, NAE Committee Advisory to ESSA, Panel on Weather Modification, Washington, C.C., November 9, 1967

NAS/NAE COMMITTEE ADVISORY TO ESSA

Panel on Weather Modification

Meeting of November 9, 1967

ESSA PRESENTATION

General Remarks		Dr. Werner A. Baum, Deputy Administrator, ESSA
ESSA Weather Modification Program and Introduction of Speakers	(15 min.)	Dr. Joachim P. Kuettner, Director, Advanced Research Projects, IER
Great Lakes Project, Brief Status Report Northeast Project Florida Project, Short Description Background Research Programs	(40 min.)	Dr. Helmut K. Weickmann, Director, APCL
Project Stormfury	(30 min.)	Dr. R. C. Gentry, Director, National Hurricane Research Laboratory
Hail Suppression	(20 min.)	Mr. Bryon B. Phillips, Chief, Atmospheric Physics Branch, APCL
Lightning Suppression	(20 min.)	Dr. Heinz Kasemir, Chief, Atmospheric Electricity Branch, APCL
Inadvertent Modification of the Atmosphere	(20 min.)	Mr. Walter Komhyr, Chief, Atmospheric Chemistry Branch, APCL
Modification of Radiation Budgets	(20 min.)	Dr. Peter Kuhn, Research Meteorologist, APCL

INADVERTENT MODIFICATION OF THE ATMOSPHERE

National Academy Panel on Weather Modification
Washington, D.C., November 9, 1967

In discussing inadvertent weather modification, I will refer briefly to two classes of phenomena that play significant roles in influencing weather and climate. One class deals with events that occur naturally, while the second encompasses man-made effects. There is little doubt, for example, that our world-wide climate would be affected if several major volcanoes erupted within a span of a few years, spewing forth large amounts of debris into the stratosphere. Yet climatic changes due to contamination of large masses of air--a condition existing in the eastern United States--or changes in climate due to cultivation of large tracts of virgin land, can be equally important on a regional basis. Although we tend to think of inadvertent weather modification as occurring slowly throughout history, we need only to take note of climatic changes that have happened in our own life time to become ware of the importance of the problem. Old timers in Arizona, for example, recall the time when the sandy deserts now surrounding them were covered with grass "belly high to a mule."

One manner in which man might be contributing to climatic change is through the introduction of carbon dioxide into the atmosphere. Measurements made at Mauna Loa Observatory in Hawaii since 1957, and at South Pole, Antarctica, indicate that the atmospheric carbon dioxide concentration is increasing at a rate of about 0.2% per year. This result is substantiated by measurements of the vertical distribution of carbon dioxide, which show the tropospheric concentrations to be greater than those in the stratosphere. There is little doubt that our industrialized society is contributing to the

observed rise in CO_2 through rapid combustion of fossil fuels that have gradually accumulated in the earth's sedimentary rocks over a period of millions of years. It happens that CO_2 is an excellent absorber and back radiator of infrared radiation. Much as glass in a greenhouse, it traps incoming radiation and causes temperatures near the earth's surface to rise. Manabe and Wetherald, writing in the Journal of Atmospheric Sciences, estimated recently that if the atmospheric CO_2 content doubled, average temperatures near the earth's surface would increase by about $2^{o}C$, while temperatures at 40 km would decrease by about $15^{o}C$. No one really knows what the effect on climate would be, though a $2^{o}C$ rise in surface temperatures may trigger the melting of polar ice-caps, and a $15^{o}C$ decrease in temperatures at 40 km may significantly alter stratospheric air mass flow patterns. A doubling of atmospheric CO_2 in the future is not difficult to envision in view of the fact that the nations of Asia, South America and Africa have yet to achieve a high level of industrialization.

But carbon dioxide is not the only atmospheric consituent that exerts a significant influence on climate. Aerosols also play an extremely important role. Not only do they increase extinction and scattering losses of solar radiation, but they also affect precipitation processes. It is well known that condensation nuclei are necessary for precipitation to occur. The presence of too many nuclei, however, may inhibit precipitation in instances where water or ice particles formed are too small to fall to the ground. As I have already mentioned, pollution of the atmosphere is no longer limited to urban areas. Our automobiles and factories contaminate vast rural air masses as well. By cultivating land we not only alter the

radiation balance of the earth-air interface, but we also render conditions favorable for dust storms. Particulate matter is also injected into the atmosphere at times of forest fires. Even the stratosphere is not free from the contaminating influence of man. Here atom bombs explode, space vehicles disintegrate, and jet aircraft leave long trails of products of combustion.

This brings me to the important, but often under-rated role, played by atmospheric ozone in the formation of climate. Ozone absorbs solar ultraviolet radiation strongly in the spectral region 2200 to 3000 A.U. Even in the visible region absorption band near 6000 A.U., a typical solar beam reaching the ground is attenuated by about 6.5%. Terrestrial radiation, on the other hand, is absorbed by ozone in a narrow band centered around 9.7 microns. Ozone, therefore, represents a heat source in the atmosphere above 20 km. As such, it contributes to the radiation balance at the tropopause and is, in fact, responsible for the existence of that distinctive feature of our atmosphere. What would be the effect on the mean height of the tropopause, hence, the effect on climate, if the mean amount of atmospheric ozone should decrease? We are aware of the fact that more and more objects are flying about in the stratosphere. Within a short time supersonic transports will be cruising at the 65,000-foot altitude which happens to coincide with the region of maximum ozone. We know that large quantities of ozone can be decomposed catalytically by small amounts of material such as carbon. The late Dr. Wexler talked about an experiment to blow a hole in the ozone layer with some catalytic agent in order to admit solar radiation shorter than 2900 A.U. to the earth's surface. Soon we will not have to do this deliberately. Supersonic transports will create not only holes but tunnels in the ozone layer.

Until now, I have talked about the influences of man on his environment. However, we must not overlook inadvertent weather modification induced by naturally occurring phenomena. Erupting volcanoes, for example, release large amounts of carbon dioxide into the atmosphere. (Indeed, volcanoes are considered to be the source of the Marsian atmosphere, comprised of carbon dioxide to the extent of about 90%.) Contamination of the stratosphere by particulate matter also occurs during volcanic eruptions. In November, 1963, for example, a 5.3% decrease in normal incidence solar radiation was observed at South Pole station due to debris flung into the atmosphere by Mt. Agung when it erupted on the Island of Bali. Dust storms occurring over arid regions of the earth also contribute significantly to the atmospheric aerosol content. Red dust from West African dust storms, for example, has been detected in the eastern United States. Even pollution of the atmosphere by plant life may be significant, as in the case of coniferous forests releasing vast quantities of terpines into the air under certain climatic conditions. We have yet to ascertain what effects these chemicals have on climate.

There appears little doubt that the problems of inadvertent weather modification deserve significant investigation. Since man and nature will continue to alter our environment, we at APCL believe it mandatory that a number of secular observatories be established throughout the world where phenomena affecting, or related to, weather and climate would be monitored indefinitely into the future. Such work, in our estimation, is best undertaken by a government agency since over-all planning will involve international cooperation. Furthermore, it is likely that only a government

agency can ensure the required long-term program continuity. That ESSA undertake a function of this type has been recommended by the President's Science Advisory Committe in a Report of the Environmental Pollution Panel, the White House, November, 1965. Within the ESSA organization it appears fitting that the responsibility lie with APCL since our laboratory deals with problems in atmospheric physics and chemistry.

To this end, a new branch ~~has recently been~~ is currently in the process of being formed within APCL. It will be ~~is~~ entitled the Secular Measurements Branch. Its objectives are the following:

1. To establish a number of secular observatories throughout the world, in cooperation with foreign governments, if necessary, where long-term measurements would be made of the agents of inadvertent weather modification. The measurements would include observations of temperature, pressure, humidity, carbon dioxide, aerosols, ozone, water vapor, atmospheric electricity, and radiation energy, near ground level and in vertical profile.

2. We will endeavor to provide, at the secular observatories, facilities and observers for use by scientific disciplines other than APCL, in particular, those disciplines also desirous of making secular type measurements, for example, air pollution laboratories interested in long-term observations of toxicants and pesticides, or of contaminants such as sulfur dioxide that are corrosive to materials; or biological laboratories interested in measurements of pollens and spores.

3. Since in many instances present-day measuring techniques are cumbersome or inadequate, we anticipate that the establishment of well defined observing programs at the secular observatories will stimulate research in instrumentation, culminating in standard methods of measurement. To attain this goal, we will support research in-house, and by way of grants and con-

tracts to other government agencies, universities, and privately owned research establishments.

4. Our ultimate aim is to gain keen insight into the processes that change weather and climate inadvertently in order that predictions might be made about future conditions. Again, basic research in relevant problems will be supported in-house, and by grants to other institutions. In instances where special investigations will involve comprehensive, short-term observational programs, e.g., to determine sources and sinks of atmospheric constituents, we anticipate that such programs will benefit immensely when the data obtained are examined relative to base-line measurements made at the secular observatories. Such programs will benefit, too, from experiences gained at the secular observatories in instrumentation and measuring techniques.

In implementing the activities of the APCL Secular Measurements Branch, we will endeavor to contact scientific institutions in this country and abroad to help develop the program. In particular we hope to work closely with the Public Health Service. To provide guidance, we anticipate the establishment of an Ad Hoc Task Group comprised of ESSA and PHS representatives, with added consultants. Basic questions requiring answers are the following:

1. Where should the secular observatories be located? Presumably, the diverse requirements of the scientific community will result in requests for observatories at a large number of locations. Budgetary considerations will, however, preclude the establishment of more than about six such sites. Currently, APCL measurements related to inadvertent weather modification are

conducted at Mauna Loa in Hawaii, and at South Pole in Antarctica. We are also tentatively planning to establish a new observatory in the mountains near Boulder, Colorado, at an elevation of 12,500 feet.

2. What type of measurements should be made at the secular observatories? Here again it is expected that a whole spectrum of observations will be proposed. Preference will, of course, be given to those measurements for which a requirement will exist during future tens or even hundreds of years. In order to utilize fully the facilities available at the observatories, however, we will not discourage the implementation of worthwhile short-term observations programs. Initially, preference will also be given to those measurements for which instrumentation and measuring techniques are well defined. Observing programs will have to be carefully planned. Whereas, certain features of the atmosphere might have to be monitored on a continuing basis, others might require only "spot" measurements, say, during one year in ten. We do not expect the observing programs at the six secular observatories to be identical.

In conclusion, I wish to re-affirm our belief in the importance of a secular measurements program such as I have outlined. To implement the program we intend to proceed slowly, seeking guidance and cooperation where ever they are available. We realize that there is no urgency to proceed "full steam ahead." By way of illustration, we have developed within our laboratory an ozonesonde capable of measuring vertical ozone distribution in the atmosphere on an absolute scale. The instruments can be used anywhere on earth in all types of weather. We are, therefore, capable of launching an ozone observations program at a number of stations where the instruments would be flown at a rate of one a day for a year or two in order that an

ozone climatology might be established. But we do not expect inadvertent causes to alter significantly the character of the atmospheric ozone distribution within the next few years. Therefore, it is not too important whether we proceed with such observations now, or five years from now. Nevertheless, we believe that such measurements should be made within the next decade, then repeated at 10 or 20 year intervals. Now, however, is the time to formulate plans for such measurements. Although at present we have practically no budget with which to work, the planning of the secular measurements program will not require a great deal of money. Initially we hope to begin work at the secular observatories with assistance from co-operating agencies. Ultimately, we envision our own budget to grow to several million dollars per year.