want it to'. For their part, the authors believe that the underlying disease causing biological and ecological disaster is poverty. This can be overcome by economic development, for example by embarking on giant projects to improve the world's transport systems, water supplies and power systems. There are no 'limits to growth'. There are in fact too few people in the world. The authors' dream is that when these great projects here on Earth are underway we can renew our efforts at space exploration and colonization. Eventually we shall transform Mars 'from a dead desert into a beautiful garden, fit for billions of human beings'.

For scientists who harbour any doubts about the wisdom of politicians in banning CFCs (in their desire to at least appear to be 'green'), this is a very disappointing book. If the authors had restricted themselves to an impartial and objective examination of the evidence, they might have succeeded in strengthening some of these doubts. As it is, the gross overstatement of their case, the virulence of their accusations—not to mention their numerous mistakes—can only be counter-productive for any thinking person. They accuse the 'ozone priesthood' of making fraudulent claims and of using scare tactics to alarm the public in order to gain support (and there may well be an element of truth in this), but they themselves are even more guilty of the same crimes. In the simplest terms, there has been a substantially greater depletion of ozone in Antarctica in each of the past ten years than in previous years, and the most convincing explanation to date is that CFCs are the main culprit. If this is confirmed, there is good reason to believe that the amount of stratospheric ozone will in due course be depleted in other parts of the world—there is some evidence that this has already begun. Even without the risks of increased incidence of skin cancer (perhaps the weakest part of the arguments of the 'ozone priesthood'), there would be a good case for replacing CFCs by some other less harmful chemicals. Politicians may have been somewhat precipitate in banning CFCs so quickly, but they are unlikely to be persuaded to change their minds by the biased misrepresentations of Maduro and Schauerhammer.

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Ozone Depletion—Implications for the Tropics. Mohammad Ilyas, ed. University of Science, Penang, Malaysia and United Nations Environment Programme, Nairobi, Kenya. 1991. pp. 374. Hardbound.

This monograph contains selected papers presented at the International Conference on Tropical Ozone and Atmospheric Change held at Penang, Malaysia, during February 20–23, 1990. The conference was the first such meeting which dealt comprehensively with all aspects of the ozone depletion problem with special reference to the tropics. This conference also provided the first professional forum at which the UNEP ozone layer review reports were presented.

Many of the papers have undergone revision by the authors after presentation at the conference, incorporating later findings or results or the conclusions as modified by the conference deliberations. As such, the usefulness of this monograph is considerably enhanced.

The volume is divided into six parts. Part 1 entitled 'Protection of ozone layer: Overview' contains seven papers of which three are devoted to overviews on different aspects of ozone depletion by independent scientists and four are UNEP Ozone layer overviews. The first paper on 'Chlorofluorocarbons and ozone depletion' is by F. S. Rowland, who was the first to point out the adverse effects of chlorofluorocarbons (CFCs) on atmospheric ozone. It contains a masterly analysis of the role played by man-made CFCs in depleting atmospheric ozone. The pioneering investigations made by himself and his group in the US from 1974 are summarized. The crucial role of the chlorine atoms contained in CFCs in destroying ozone by a kind of catalytic chain reaction is stressed and the predictions made in 1974 about an eventual loss of 7 to 13% of global ozone, resulting from continued emissions of CFCs into the atmosphere, are discussed. For a test of their 1974 calculations, balloon-borne measurements of CFC concentrations were made in 1975 in the US by NASA and NCAR groups up to altitudes of 35 km. The close agreement between the theoretically predicted vertical distributions and the experimentally determined ones is remarkable. A slight but significant decrease in total ozone over the high and middle-latitudes observed in recent years, and the phenomenon of the 'Antarctic ozone hole' is then discussed. The flights made by ER-2 aircraft into the Antarctic polar vortex at heights of 18 to 19 km to measure concentrations of chlorine oxide (ClO) and ozone (O_3) revealed spectacular results. The sudden decrease in ozone mixing ratio while traversing certain latitudinal belts is accompanied by an equally sudden increase in the ClO mixing ratios, thus establishing conclusive evidence that ClO is the primary agent responsible for the ozone loss in Antarctica. In conclusion Rowland observes—'My recommendation made first in 1974 has now been adopted globally—all uses of CFCs should be eliminated'.

The second overview is by J. C. Farman, who was the first to report ozone depletion over Antarctica in 1985. It deals primarily with the formation of the 'Antarctic ozone hole' and its link with chlorine and ClO. The sequence of atmospheric processes leading to the 'hole' are: transport of ozone and photodecomposition products of halocarbons deep down into the polar stratosphere, the isolation of polar air as the winter vortex develops, condensation at very low temperatures of nitric acid hydrates forming polar stratospheric clouds, conversion of stable chlorine compounds to less stable forms on the surfaces of nitric compounds in these same particles, the release of ClO and Cl_2 radicals when sunlight returns and finally the extremely rapid ozone reduction. Vertical soundings of ozone concentration made at Halley Bay, Antarctica before and after the development of the 'ozone hole' during 1987 are presented, showing that at the ozone

peak at 16.5 km, the depletion was as high as 97.5% and the columnar ozone depletion was about 57%.

In the next article by M. Ilyas, the results of measured UV intensities at Penang are compared with those computed for average cloud cover. He also presents the results of calculations made on UV-B intensities at different latitudes for unperturbed ozone conditions and for an assumed 10% decrease in total ozone. The author points out that the harmful effects of UV-B will be particularly felt in tropical regions, where even normal levels of UV-B are very high. However, to assume a uniform 10% decrease in column ozone at all locations over the earth, appears to be incorrect. As has been shown by careful analyses of both ground-based measurements (A. Mani) and Nimbus-7, satellite data (R. S. Stolarski) described elsewhere in the monograph, there has not been any statistically significant decrease of ozone in the tropical regions during the past two decades or so. In view of this, the assumption of 10% decrease in ozone would result in overestimates of UV-B in the tropics. The next paper by R. T. Watson summarizes the UNEP Science Panel Report (1989) and recommends complete phase-out of all fully halogenated CFCs, halons and carbon tetrachloride to prevent the recurrence of the 'Antarctic ozone hole'. A discussion on ozone trends in the northern hemisphere as evaluated by the International Ozone Trends Panel using ground-based Dobson data follows. After eliminating natural variability, the analysis showed a decrease of 2.3–6.2% between 30° and 64° N latitude for the winter months from 1969 to 1986. Detailed analysis of what would happen to chlorine levels during the next century, if CFCs are substituted with other compounds like hydrogenated CFCs, with reduced life times in the atmosphere, are presented. Even if control measures of the Montreal Protocol were to be implemented by all nations, the present atmospheric abundance of chlorine (about 3 ppbv) will double or even triple during next century and ozone depletions of 0–4% in the tropics and 4–12% at high latitudes would be predicted. The article by J. C. Van der Leun summarizes the effects of UV-B radiation on human health, terrestrial plants, aquatic ecosystems, tropospheric air quality and materials damage. The overview by G. V. Buxton deals with the technical feasibility of the Montreal Protocol, 1986 and analyses the world consumption of controlled CFCs and the various options for projections for phased withdrawals of these by the year 2000. The last overview by J. Lupinacci deals with the economic implications of the Montreal Protocol and suggests economic strategies to be adopted by developing nations in the gradual switching over from CFCs to HCFCs and HFCs.

Part 2 on 'Stratospheric ozone and UV radiation measurements' contains seven papers. The first paper by W. A. Mathews presents the vertical ozonesonde profiles at Landers, New Zealand, on two typical days, one with a high total ozone and a low tropopause and the other with a low total ozone and a high tropopause. Also presented is a hemispherical map illustrating how a swath of ozone-depleted air, torn off from the Antarctic air mass at the breakup of the polar vortex, moved over southern New Zealand and south Australia bringing low ozone concentrations.

In the next paper, A Mani traces the history of ozone measurements in the tropics during the past sixty years with special reference to investigations in India. The distinctive features of ozone variations in the tropics are presented using Dobson spectrophotometer data. After analysing the data of seven tropical stations for the period 1960–88 (four in India and three elsewhere) she came to the important conclusion that no significant trend is detectable in the average column ozone in the tropics. The paper by R. S. Stolarski presents the results of measurements of tropical total ozone made by the Total Ozone Mapping Spectrometer (TOMS) mounted on the Nimbus-7 satellite. The period covered by the analysis is 11 ½ years ending in May 1990. Using a new method for correcting for the drift in the calibration of the TOMS diffuser plate, the author recalculated the trend (earlier calculation presented at the Penang conference was minus 1–2% per decade) and found it to be only −0.5% per decade. This important finding is in conformity with the results obtained by A. Mani in the earlier paper based on ground-based data.

Results of total ozone measurements made at Singapore during the period 1979–89 are presented by Thulasidas in the next paper. The general variation can be explained mostly by low frequency fluctuations in the QBO and it is difficult to isolate any long-term effects due to ozone depletion. A solar and skylight spectrophotometer designed and built at the State Meteorological Service, Beijing, China is briefly described by Q. Y. Xue in the next paper. Using the direct sun, direct moon or skylight as the source, the instrument can measure column abundance of ozone, NO_2 and NO_3. Comparison of ozone determinations made with this instrument and Dobson spectrophotometer data shows percentage errors ranging from 0.3 to 6.0 in a sample.

The paper by C. R. Roy and H. P. Gies presents results of solar UV-spectral measurements made at Yallambie (38° S) in Australia, using a microcomputer-controlled spectroradiometer incorporating a double grating monochromator, and of broad band UV measurements made with a simpler type instrument at 10 locations in Australia and 4 in Antarctica. For a decrease of total ozone from 305 DU to 273 DU during December 1987, the UV radiation increase was found to be 50% at 279 nm, 25% at 303 nm and effectively 0% at 325 nm at Yallambie. A comparison of observed UV with those obtained through model calculations is also presented.

R. E. Basher's paper discusses ozone impacts on solar UV radiation and monitoring strategies. He points out that although the ultimate human concern stemming from the recent phenomenon of world-wide ozone depletion is the increased UV-B radiation and its biological impacts, no global programme exists for the actual measurements of UV-B radiation of the type that exists for ozone measurement. He stresses the need for establishing standards for UV radiation units, instrument standards and calibrations and for the establishment of an international coordinating group similar to the International Ozone Commission to take responsibility in evolving suitable standards and procedures for solar UV measurement. In view of the difficulties involved in accurate UV measurement, calculations will have to be done to

complement and extend measurements using simple statistical models.

Part 3 deals with tropospheric ozone measurements. The first paper 'Ozone in the tropical troposphere' is a review article by I. E. Gallbally and R. C. Roy, presenting our current knowledge of ozone in the tropical troposphere, the sources and sinks, the cycles of ozone over remote tropical oceans and over continents under unperturbed conditions and under biomass burning, and in tropical urban areas. The lowest ozone content is observed over remote islands in tropical oceans and highest ozone over continents following biomass burning. The photochemistry of urban polluted atmospheres involving oxides of nitrogen and other trace gases is also discussed.

The article entitled 'Indication and causes of ozone trends in the planetary boundary layer over Western Europe' by R. Guichert deals with the contribution to tropospheric ozone through downward transport of stratospheric ozone through tropopause gaps and the *in situ* production of ozone in the lower troposphere, by photochemical processes involving oxides of nitrogen and hydrocarbons. Seasonal and diurnal variations of ozone in the planetary boundary layer in Western Europe are also discussed. While determining trends in ozone levels in the troposphere the author stresses the need to consider only those in the less polluted background or rural areas and not urban areas.

The next four papers by different authors present results of surface ozone measurements made at such widely separated locations as Karachi (Pakistan), Watukosek (Indonesia), Bandung (Indonesia) and four stations in Japan. All measurements reported in these papers were made with instruments based on UV-absorption techniques and suitably calibrated. Measurements at three sites in metropolitan and suburban areas at Karachi indicate that one site, away from the city's polluted atmosphere, has lower ozone concentration than the other two located within the city. The results for Watukosek show a diurnal variation typical of tropical locations. Vertical mixing and photochemical production enhance day time concentrations. The situation at Bandung (West Jawa) is somewhat similar. At a higher latitude like Tsukuba (Lat. 34° N), surface ozone shows a maximum in spring suggesting that transport from the upper troposphere to the surface is more active in these latitudes. The vertical distributions of ozone and water vapour over two stations in Western Pacific are presented.

Part 4 with four papers deals with the important topic of the biological and climatic effects of ozone depletion. The first paper by J. C. Van der Leun discusses the effect of ozone depletion on human health. Cumulative exposure to UV-B could lead to increased incidence of cataract of the eye and for every one per cent decrease in ozone there could be 0.6% increase in cataracts. Non-melanoma skin cancer which affects white populations preferentially has been found to increase by 3% for every 1% depletion of ozone. In regard to cutaneous malignant melanoma (CMM), the author reports somewhat contradictory findings between different groups of investigators but confirms the role of UV-B in the etiology of CMM. UV radiation has been found to alter both locally and systemically, the immune response (ImR) to antigens administered via the skin in man and animals. The UV-B is thought to be responsible for suppression of ImR, thereby increasing the chances of tumour development in patients already affected by UV-B.

The paper by M. Tevini reports that plant growth characteristics such as height and leaf area are reduced in UV–B-sensitive plants to different extents depending on the plant species and cultivar. The increases in UV-B used in the experiments were rather too high, being 25%. Out of 80 cultivars of 12 species of soybeans studied, 41% were tolerant or unaffected by UV-B. During the coming decades other environmental changes will be superimposed on the UV-B increases, like temperature and CO_2. The author stresses the need for experiments to study whether these additional factors could compensate for the deleterious effects of UV-B.

The article on ozone reduction and tropical vegetation by M. M. Caldwell dwells on the latitudinal gradient of UV-B radiation, the spectral energy contents in the UV-B radiation and the action spectrum for various biological effects. The adaptation of plants originally belonging to temperate regions but transferred to tropical areas with higher UV-B is discussed. Of particular interest is the finding that a few plants growing naturally under field conditions do not show damaging effects when subjected to additional UV-B dosage from fluoroscent lamps but the same undergo damages when irradiated in glasshouses or in laboratories.

D. M. Olszyk and K. T. Ingram discuss the effects of UV-B and global climate change on rice production. Rice is the staple food for over half of mankind, with at least 2 billion people in Asia alone depending on rice for much of their calorie intake. Among the recent findings on UV-B effects the following are noteworthy: UV-B itself can induce accumulation of UV-absorbing pigments and alter leaf surface characteristics and it remains to be investigated whether these responses are sufficient to give protection to rice from increased exposure to UV-B. Substantial variation exists both in magnitude and direction of UV-B response among different rice cultivars. Identification and/or breeding of UV-B-tolerant cultivars may be an important means of adapting to potential effects of ozone depletion. Although some information is available on the separate effects of UV-B, CO_2 and temperature, the interactive effects of the three factors are largely unknown at present, although in the real world situation all the three factors could change simultaneously. Controlled experiments are needed to elucidate the problems and solutions.

The paper by D. P. Hader and R. C. Worrest presents the UV-B effects on phytoplankton which inhabits the upper layers of water bodies and provides food for a variety of marine species and hence provides sea food for humans via a sea food web. The authors conclude thus: Due, to the enormous size of the phytoplankton ecosystems in the vast oceans, even small UV-B radiation-induced decreases will lead to large losses in biomass production. These losses will be relayed through the whole intricate biological food web and ultimately affect global food supply. The phytoplankton ecosystem in the oceans is the largest sink for atmospheric CO_2; any decrease in phytoplankton populations will decrease the sink capacity for CO_2.

Part 5 on 'Effects of climatic change'

contains three papers. The first by P. H. Whetton and A. B. Pittock discusses the different models that predict various levels of temperature increase caused by global increase in CO_2 and other greenhouse gases in the atmosphere. While sounding a note of caution on the many uncertainties involved in modelling and other assumptions, they summarize the climatic effects. For the tropics, an equilibrium temperature increase of 2–4°C is predicted by the year 2050 for doubling of CO_2 level which may occur by 2030. A general increase of tropical rainfall is also predicted but this may not be homogeneous over all areas. The response of the El Niño Oscillation (which exercises a profound influence on climate and weather) to greenhouse forcing is unknown and this makes the rainfall estimates uncertain. The tropics may suffer a sea level rise at 30 ± 20 cm by 2050. The second paper by W. C. Wang discusses changes in radiative heating in the stratosphere, troposphere and on the ground due to assumed changes in the concentration of CO_2, methane and several other greenhouse gases. The annual mean surface temperature of the earth is estimated to rise by 2.5°C by 2050 with larger warmings at high latitudes. Warmings of 8–9°C could occur in the lower stratosphere and the tropical upper troposphere. Large stratospheric cooling is predicted for all latitudes and seasons, with a maximum cooling of 12°C at 45 km. These changes could affect tropical climate significantly. Large uncertainties in the predictions from greenhouse effect could arise, because of different treatment of feedback effects of clouds in the different climatic models used.

The next paper by M. B. Prendez deals with the special problems facing the country Chile in relation to ozone depletion because of its close proximity to the 'Antarctic ozone hole'. He pleads for the establishment of solar UV-monitoring stations in Chile to assess quantitatively the impact of increased UV on the health of humans and plants in Chile, which could come under the influence of ozone-depleted air advecting from the Antarctica.

The last paper by M. R. Riches and A. A. Patrinos describes the global change research within the US Department of Energy, such as the CO_2 research programme.

The last part on 'Alternative technology, Montreal Protocol and the developing countries' deals with the Montreal Protocol of 1987. G. V. Buxton gives the key features of the Protocol and the major issues arising from the renegotiation of the Protocol now under way. Alternatives to CFCs, now available for the refrigeration industry, are discussed in detail by L. K. M. Kuijpers, together with the economic implications of the substitution. Similarly, substitutions to CFCs, as blowing agents in foam plastic industries, are discussed by J. M. Lupinacci. Alternatives to CFCs in the manufacture of aerosol products are described by I. Kokeritz. Problems encountered in complying with the Montreal Protocol in Malaysia are dealt with in the article by K. S. Goh. Finally, adjustments/amendments of the Montreal Protocol proposed by different signatories are enumerated by G. V. Buxton.

The book, containing as it does, a collection of original papers and excellent reviews relating to many specialized areas in the field of global ozone depletion, is a very useful monograph and should find a place in libraries, scientific institutions and universities interested in the subject. The printing, binding and get up are of a high standard.

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