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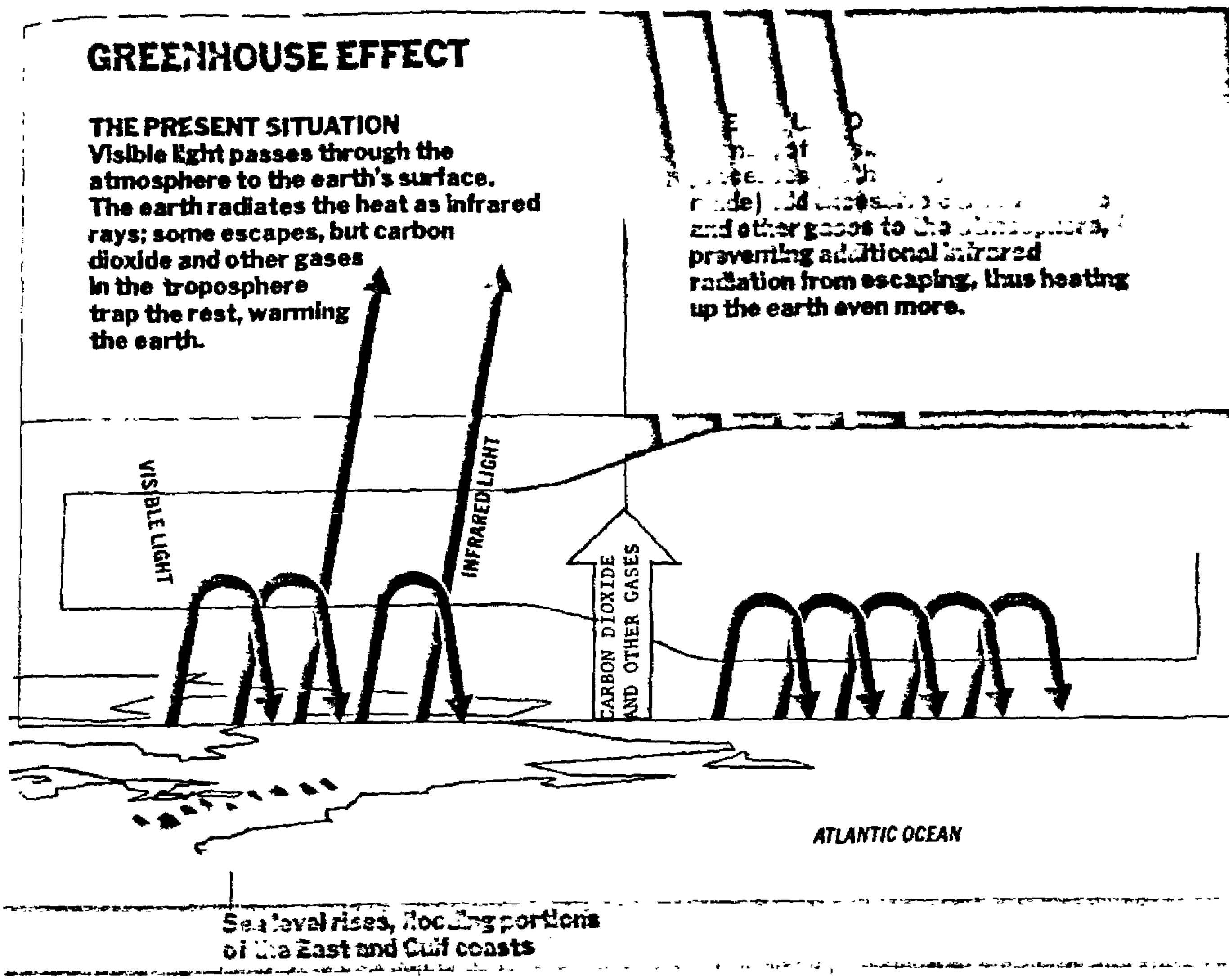
The Heat Is On

Chemical wastes spewed into the air threaten the earth's climate

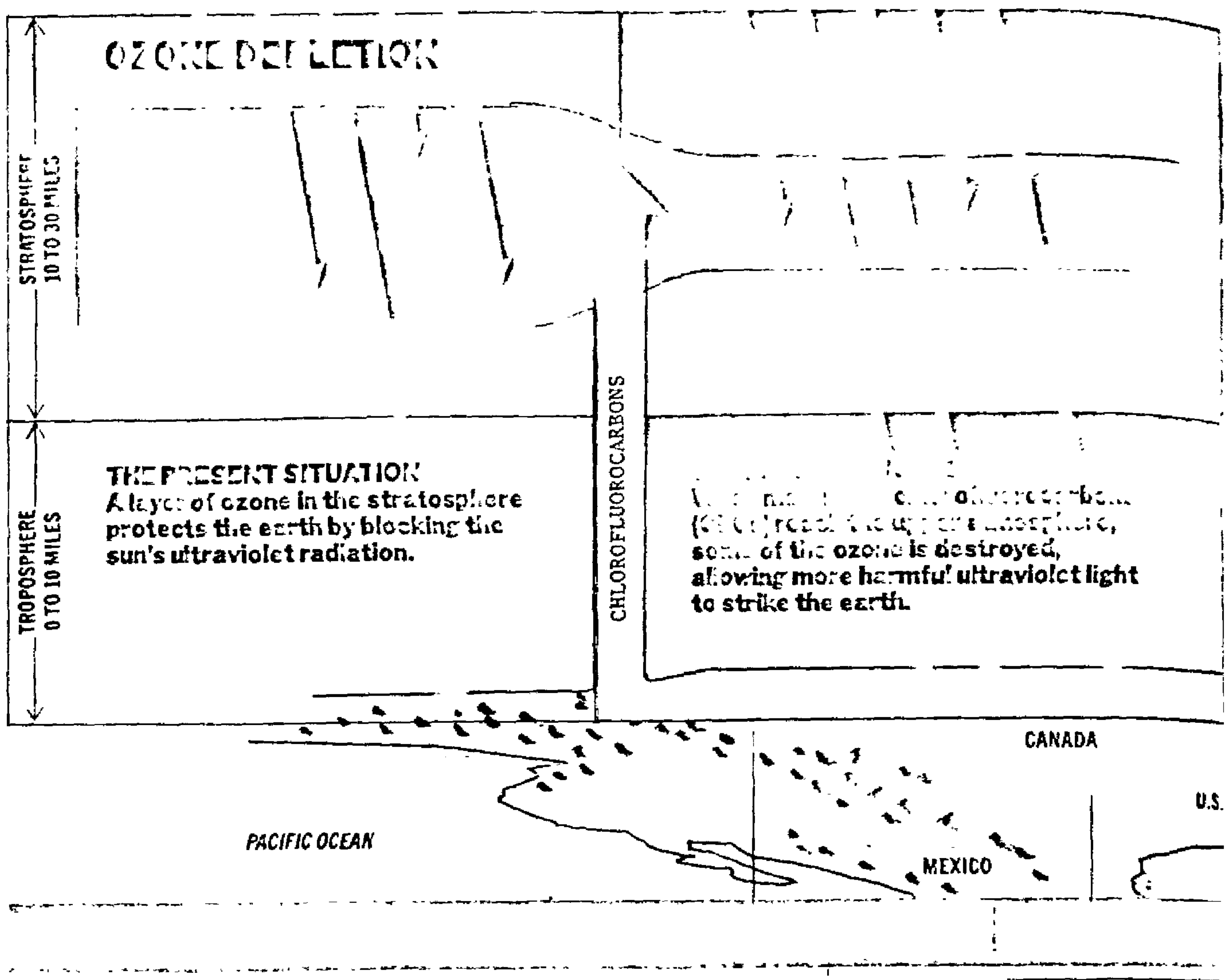


TIME, OCTOBER 19, 1987

These diagrams refer to North America but Climate Change effects will occur in all our countries, and will mean :

- **rises in sea level** : some Pacific islands may disappear and low countries and coasts be flooded
- fertile regions becoming **deserts** and cold areas becoming warmer
- more **tropical storms**
- **skin cancers** will increase because more of the sun's ultraviolet light gets through (see problems with the ozone layer next page)

(Newsletter Nov. '86 article - The Greenhouse Effect)



TIME. OCTOBER 19, 19

It is true that many YWCAs are busy with human rights, the struggle for freedom and justice, or refugee programmes, and have very little time and energy left to lobby and work with their governments (who may in fact be hostile) on changing the activities that are causing the warming of the earth and the destruction of the atmosphere. But why are we working with these women refugees, or in programmes for disturbed young people in cities, if in fact there is no future ?

LET US SECURE THE FUTURE

Work with consumer associations and form coalitions of many organisations to :
- ban the burning of coal, oil shale, and bring in laws to cut smoke emissions and pollution from factories
- introduce lead free petrol
- ban spray cans which use chlóroflurocarbons
- stop all cutting of rainforests and develop large reafforestation programmes
- improve water storage for small scale systems (not big dams)
- pressure all governments to preserve all plants and strains of wild genes for the day when new crops will be needed.

SAVE ENERGY

In your YWCA do not use the spongy polystyrene for throwaway cups, or hamburger cartons, and avoid plastics where possible - they are indestructible and when burned or crushed in garbage dumps the CFCs escape into the ...ere.

We have **a list of safe brands of aerosols sprays available** ... which will go **with this newsletter to all UK Ys EYEs.**

…rine blamed for growing 'ozone hole'

…e acid on lace, chlorine from man-made chemicals …pears to be eating away the tenuous fabric of our …tective ozone layer, at least over Antarctica in spring. …at's the nearly inescapable conclusion from the most …cent set of stratospheric measurements made last year … more than 150 scientists, who flew their most …phisticated instruments into the centre of the now-…nowned 'ozone hole'.

…ey found that the diffuse ozone layer, …read out between 12 and 20 km above … icy continent, registered in August a …ickness equivalent to 3·0 mm at sea level, …ut by early October — as the sun returned …ter the long winter night — it had been …educed to only 1·3 mm. Other instruments …owed that at the heart of the ozone layer … at an altitude of 16 5 km — more than 97% of the ozone had been consumed

Fortunately, within a further month or so, the 'hole' had been repaired, as air with normal ozone levels swept in from lower latitudes (just as has happened every year since the springtime ozone hole apparently first came into being 9 years ago) The filling-in of the hole results from the natural changeover between winter and summer circulation patterns in the Antarctic atmosphere.

Nevertheless, the phenomenon has scientists worried, because the hole is getting progressively deeper and wider each year (apart from a slight turnaround in 1986). Last year's hole had 15% less ozone than the previous minimum in 1985, and represents a thinning of ozone of more than half

Furthermore, last year the filling in of the hole occurred later than it ever had (mid December). This could be the first observed result of the ozone hole having an impact on climate

Because ozone shields living things from the sun's damaging ultraviolet radiation, the possibility that the Antarctic ozone hole is the forerunner of thinning elsewhere in the stratosphere has profound implications for future life on earth Thankfully, the hole is presently confined to an isolated air mass (the very cold vortex of air that swirls in constant darkness around the South Pole every winter), and the chemistry of its formation is different from that governing the stratospheric ozone sheltering the rest of the globe.

However, if ozone at temperate latitudes were to disappear at a similar rate, we'd really have something to worry about (more skin cancer, reduced crop yields, diminished phytoplankton activity, and so on). An unrestrained growth in the release of man-made chlorofluorocarbons (CFCs) to the atmosphere could bring this about, scientists warn.

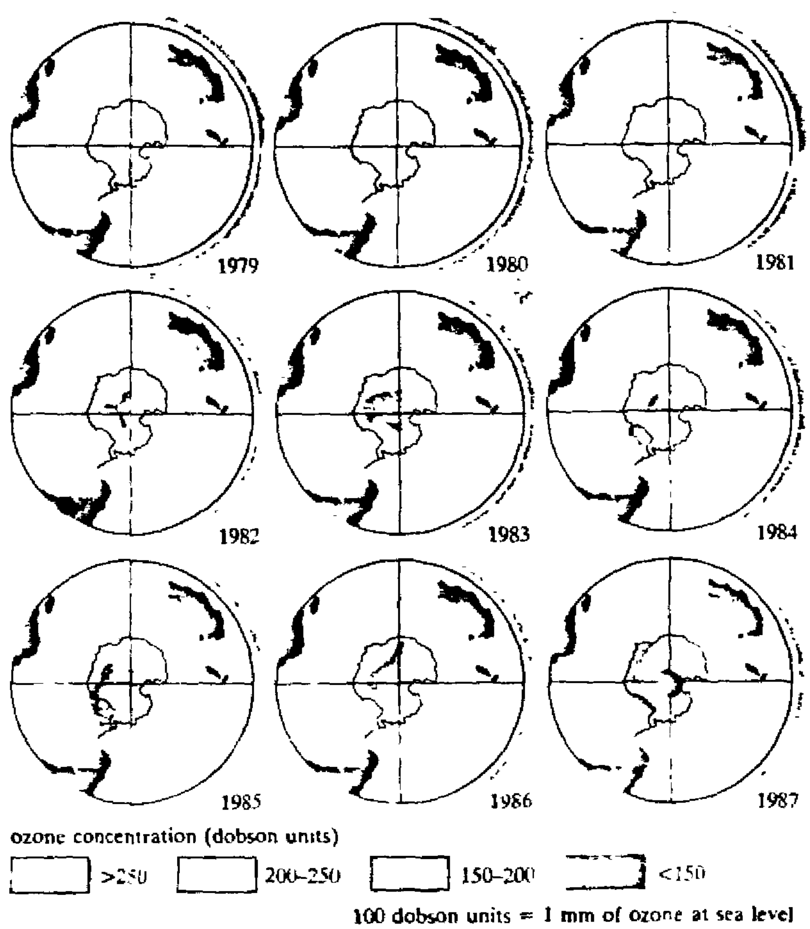
So fa: th… only significant long-term ozone change found outside Antarctica has been a 2-[illegible] since 197[illegible] in the mid to high latitudes of the Northern Hemisphere. This loss was revealed in March this year by NASA's Ozone Trends Panel. (Dr Alan Plumb and Dr Paul Fraser, of the CSIRO Division of Atmospheric Research, belong to the Panel, and they have contributed to its recent comprehensive report on atmospheric ozone.)

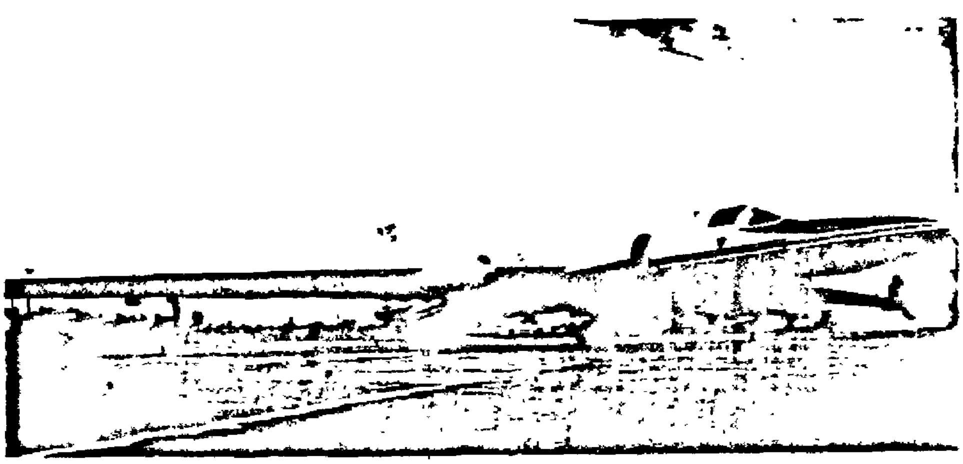
With the current ozone-observing network, such an ozone change is barely detectable because many processes affect global ozone levels, often in opposite directions. The gas is constantly created (by sunlight from ordinary oxygen, mostly above the Equator) and destroyed (by various atmospheric constituents, natural and man-made) as winds distribute it in the upper atmosphere Cyclical changes in atmospheric motion and variations in solar activity with the solar cycle can have a big influence on these processes.

Reports last year of large decreases in total ozone since 1979 (and of the appearance last year of a small Arctic ozone hole)

Satellite measurements have shown a progressive decline in springtime ozone levels over Antarctica. How long can the decline continue?

How the hole has grown





The ER–2 high-flying aircraft that went into the Antarctic stratosphere to take samples and analyse the chemical content of the air there.

have now been shown to be incorrect; they were due to satellite data that failed to allow for drifts in sensitivity of the on-board detectors.

The key question is whether the Antarctic ozone hole is a symptom of something far more drastic — is it an early warning sign of what may happen over the whole planet if increased quantities of CFCs are released to the atmosphere?

Another worry, voiced by Dr Plumb, is that Australia may already be feeling some effects from the loss in Antarctic ozone. Last spring, the Antarctic hole covered 15% of the Southern Hemisphere, and when it filled in it most likely did so at the expense of neighbouring regions. Dr Plumb suspects that an early summer depletion in Australian ozone levels may now be detectable, and he is keen to see if analysis of surface and satellite ozone data for the Australian region confirms his suspicions.

Montreal Protocol

As *Ecos 52* pointed out, atmospheric concentrations of CFCs — used as refrigerants, blowing agents in plastic-foam production, propellants in some spray cans, degreasers of electronic assemblies, and so on — are rapidly increasing. Inert in the lower atmosphere, these gases slowly migrate to the stratosphere where ultraviolet radiation breaks them down, creating very reactive radicals of chlorine and chlorine monoxide ($Cl^\bullet$ and $ClO^\bullet$) and starting a chemical chain reaction. The radicals act as catalysts, with each one formed leading to the destruction of thousands of ozone molecules (O_3) into oxygen (O_2). The most common CFCs in the atmosphere have an effective lifetime of 75–110 years.

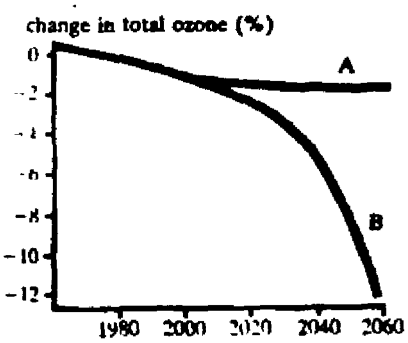
Placing a ceiling on the release of CFCs into the atmosphere is the aim of the historic Montreal Protocol, agreed to last September (2 weeks before the latest ozone hole findings became known) under the earlier Vienna Convention for the Protection of the Ozone Layer. Australia is one of the countries, along with the United States, the European Economic Community, and many other nations, that have ratified the Protocol or are about to do so.

The Montreal Protocol for Substances that Deplete the Ozone Layer calls for a freeze (at 1986 levels) on the national consumption, but not production, of CFC-11, -12, -113, -114, and -115 by 1990, followed by a 20% cutback before 1994 and a further 30% cut before 1999. In addition, consumption of halons 1211 and 1301 (bromine-containing compounds used in some fire-extinguishers) will be frozen at 1986 levels by 1993. We use 40 times less halons than CFCs, but then they destroy ozone up to 10 times more effectively.

Developing countries received a 10-year period of grace, during which they would be allowed to steadily increase annual consumption of CFCs to 0·3 kg per person, which compares with a present average of about 0·8 kg in developed countries, such as Australia (this country currently consumes 12–13 million kg of CFCs each year).

Curve A models the effect on ozone if CFC emissions cease in 1997 (prior emissions detailed in text). In an alternative scenario, non-compliance with the Montreal Protocol sees one-third of the current world CFC production increasing by 2·5% per year — a path to major ozone depletion.

The outcome of two patterns of CFC use



The required reductions are measured in ozone-depleting potential, not tonnes. In other words, a country can increase its consumption of CFCs, but still reduce environmental impact, by switching to CFCs with shorter atmospheric lifetimes and lesser ozone-destroying abilities.

Of course, a big drive is now under way for companies to come up with new CFCs that possess minimal ozone-consuming side-effects (and are not too expensive to make). Normally competitive companies are co-operating to find alternatives in the shortest possible time. Nevertheless toxological testing of proposed substitutes will take about 5 years, and implementing changes to production facilities may take even longer.

The Protocol is a landmark achievement — the first international treaty to limit the pollution of the planet's atmospheric mantle.

Dr Fraser, a scientist with broad expertise in the effects of trace gases on ozone, believes the measures prescribed by the Montreal Protocol are probably sufficient to prevent long-term depletion of the ozone layer outside Antarctica, provided we are correct in assuming that the simultaneous release of carbon dioxide, methane, nitrous oxide, and other greenhouse-effect gases brings about a countervailing effect to that of chlorine on ozone levels.

Increased levels of these gases (that incidentally include CFCs themselves) trap extra heat low in the atmosphere, which calls for a corresponding cooling in the stratosphere to balance the energy budget. This cooling slows ozone-depleting reactions, and in addition methane acts to some extent as a chlorine 'sink'.

If we use a widely accepted model of ozone chemistry to examine the net result of these two effects, we get the ozone levels shown in the graph. Curve A shows what happens if the Protocol's provision for a 20% reduction from 1986 levels in consumption of CFCs has a compliance rate of 65%. It assumes that non-complying countries continue to emit CFCs at a growth rate of 2·5% per year until 1997, when growth stops. The final ozone depletion is less than 2% by the year 2060.

In another possible development, non-complying nations may continue to increase CFC usage at 2·5% per year indefinitely, and curve B shows the worrying result — an ozone depletion of 12% by 2060.

These predicted depletions are based on chemical processes that have been thoroughly investigated over the past 20 years, and they form the scientific basis of the Montreal Protocol. Scientists currently believe that adherence to this Protocol will [illegible] future global ozone depletions from reaching unacceptable levels (outside Antarctica). However, they are now seeing that chemical processes, previously thought unimportant, are causing the Antarctic ozone hole; a substantial effect on regional ozone concentrations is resulting even from present chlorine levels (previously regarded as 'safe')

Because we are currently putting CFCs into the atmosphere five times faster than natural processes can dispose of them, the amounts of CFCs in the atmosphere will still be increasing even after the envisaged 50% cuts have taken place in 1999. If we wanted the amounts of atmospheric CFCs to grow no bigger, and the Antarctic ozone hole to stop deepening, we would need to cut their emissions by 85%.

As the Protocol stands at the moment, by 2020 stratospheric chlorine levels will be about three times the present level (10 times the amount present before use of CFCs became widespread).

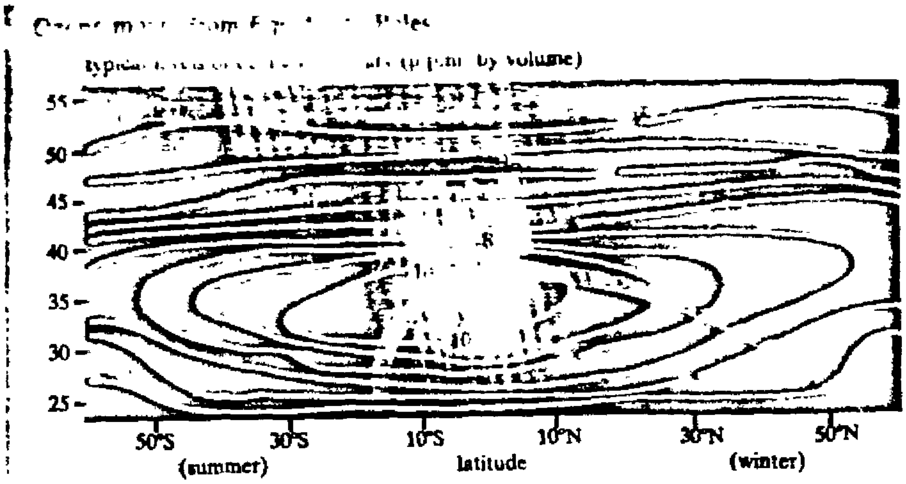
Maybe if the Montreal delegates had known the results of the latest Antarctic probings they would have made the emission limitations more stringent. Fortunately, the Protocol contains provisions for reassessments, and these must be undertaken at least every 4 years

Chlorine is it

The latest Antarctic probings involved international teams of scientists and technicians operating high-flying aircraft out of southern Chile between 19 August and 30 September last year. Managed by NASA, the Airborne Antarctic Ozone Experiment saw researchers from agencies and universities in the United States, Britain, and several other countries working together to find the cause of the recurring Antarctic hole.

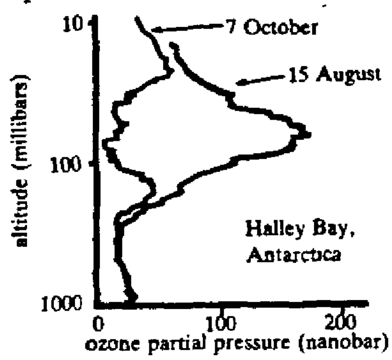
An ER-2 aircraft made 12 sorties from Punta Arenas (Chile's southernmost city) as far south as 72° and at altitudes up to 19·5 km, carrying sensitive instruments to measure the chemical content and meteorological properties of the air A larger modified DC-8 made 13 flights; this heavily instrumented plane was limited to an altitude of 11·1 km, but it reached the South Pole on several occasions, and finally flew right across Antarctica to New Zealand The scientists also made use of ground-based and satellite observations.

When the Experiment's initial findings were released on 30 September, it was immediately apparent that chlorine, acting within the unique Antarctic meteorology, was to blame for the ozone depletion. As the ER-2 flew into the ozone hole, and ozone levels dwindled, the concentration of chlorine monoxide (the smoke from the CFC gun) rose steeply; indeed, small variations in one quantity were matched by opposite deviations in the other



Ozone is formed by sunlight — mostly above the Equator. Its predominant movement is from the Equator towards the winter Pole. Because the lower atmosphere is denser, most of the ozone can be found below 35 km (the peak in relative abundance).

A profile of the 1987 ozone hole



At a height of 16·5 km (70 millibars) the ozone concentration fell by 97% from the level recorded on 15 August 1987, before the 'hole' formed.

The 1987 measurements confirm those of 1986, which revealed particularly low levels of NO_x, thus ruling out the solar cycle theory (wherein increased solar activity produces high levels of ozone-destroying nitrogen oxides)

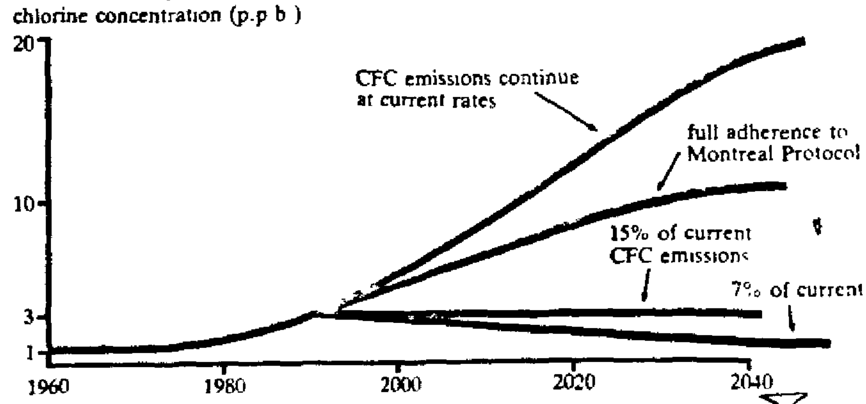
The purely dynamical theories are not looking too good, either. Dr Plumb, an expert in the atmospheric dynamics of ozone transport, once favoured this sort of explanation, but he now believes that observations don't support any such picture.

For example, the most popular dynamical theory — that ozone is depleted because the Antarctic sunrise causes upwelling from below — is incompatible with measurements of nitrous oxide (N_2O) and CFCs. These compounds, originating at the surface, should increase in the stratosphere if upwelling is going on. They don't!

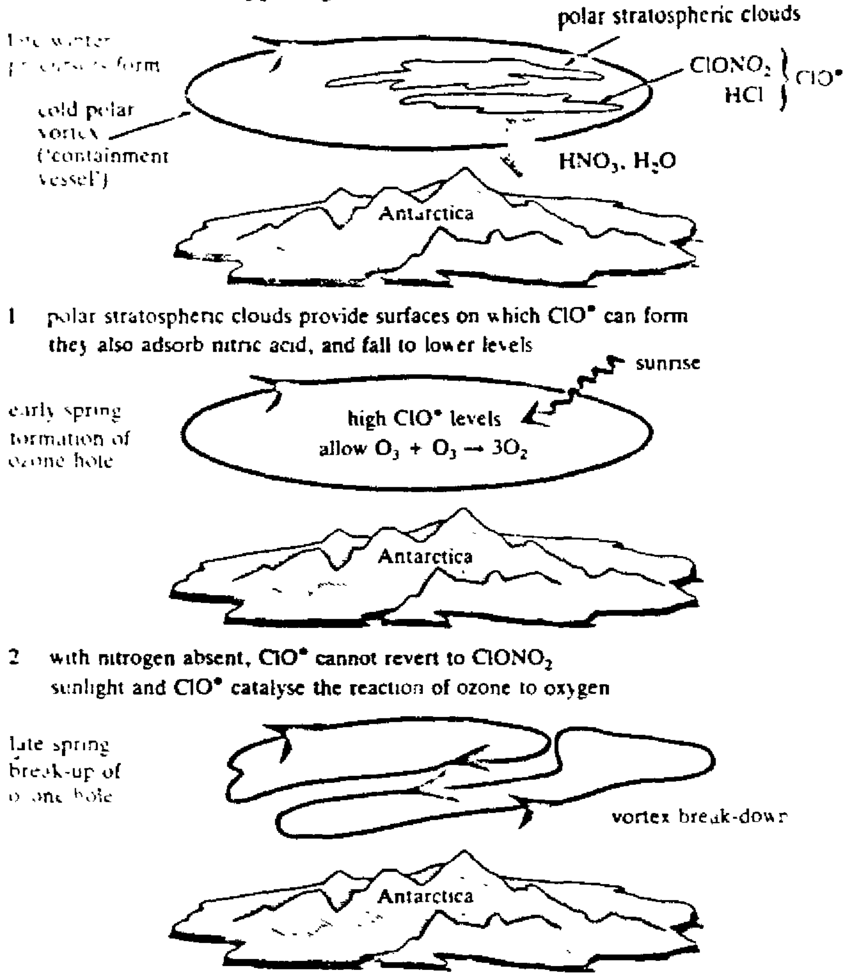
And so, the chlorine theory seems to have come up trumps The big question is

If we want to see a turnaround in the rising levels of stratospheric chlorine, we will need to cut emissions of CFCs to less than 15% of current rates. However, it should be noted that, although chlorine is the primary cause of ozone depletion, the concentrations of the two can't be directly related. In particular, chlorine is kept out of harm's way when it reacts with methane, and one of the incidental effects of accumulating greenhouse gases is to lower stratospheric temperatures and so favour ozone production.

Trends in stratospheric chlorine



What seems to be happening



1 polar stratospheric clouds provide surfaces on which $ClO^•$ can form they also adsorb nitric acid, and fall to lower levels

2 with nitrogen absent, $ClO^•$ cannot revert to $ClONO_2$ sunlight and $ClO^•$ catalyse the reaction of ozone to oxygen

3 warming breaks up the polar vortex and the ozone hole is filled by air with normal ozone levels

no longer whether CFCs are responsible for ozone depletion, but rather how they do it.

Most researchers believe that the key lies with chemical reactions that take place on the surface of frozen particles in polar stratospheric clouds. The dark Antarctic stratosphere, isolated in the polar vortex, is intensely cold, reaching −85°C or lower; under these conditions water vapour passes the frost point and ice crystals form.

According to current theory (incomplete though it is), reactions on these crystals provide a reservoir of reactive chlorine that destroys ozone when the sun returns in the spring. Basically, the ice surfaces are required to convert chlorine from inactive forms (such as $ClONO_2$ and HCl) into active forms like $ClO^•$

To explain the observed ozone loss, the theory requires $ClO^•$ levels of 1 part per billion — an amount at least 100 times greater than the normal stratospheric concentration. It further predicts that these high levels of $ClO^•$ should be accompanied by low amounts of NO_x and H_2O because the cloud particles fall, taking away both ice and nitrates. W[illegible]

acid out of the way, chlorine is free to destroy ozone.

Indeed, these predictions have received strong support from the recent Experiment. Levels of $ClO^•$ did reach 1 p.p b in a clearly defined region above 18 km and poleward of 68°S; NO_x and H_2O levels fell abnormally low, and high levels of nitrate were sometimes observed in collected ice particles.

The fast reaction between HCl and $ClONO_2$ in the presence of ice particles has recently been studied in the laboratory. It appears that chlorine gas (Cl_2) is liberated from ice particles and oxidised to $ClO^•$, while nitric acid (HNO_3) stays absorbed on them — just as required by the chlorine-blaming ozone-hole theory.

The theory also explains why an ozone hole appears in the Antarctic but not the Arctic: the Arctic stratosphere is perhaps 10° warmer (the polar vortex is not so strong there), and so stratospheric clouds are much less common.

It is becoming clear that meteorology sets up the special conditions required for the unusual chemistry. Scientists are now [illegible] a finely tuned system involving photochemistry and stratospheric circulation.

They are talking of the polar vortex creating a stratospheric 'containment vessel' in which ozone chemistry could proceed without being influenced by mixing with air below or outside. The ER-2 flights showed that the ozone hole remained well inside the vortex.

Why has the ozone hole formed and deepened so quickly, while CFC concentrations have been steadily increasing at only about 5% per year? Perhaps a slight upset in stratospheric circulation precipitated a major change in the chemistry of the containment vessel, some scientists are thinking. Thus, maybe a small reduction in temperature triggered the dramatic deepening of the ozone hole by increasing the amount of polar stratospheric clouds. Alternatively, perhaps the amount of ozone depletion depends very sensitively on the concentration of reactive chlorine (that is, there is a threshold effect).

For the future, two major questions remain outstanding, according to Dr Plumb:

- ▷ How, and to what extent, does the depth of the ozone hole depend on the level of stratospheric chlorine — ultimately, how deep can the hole get?
- ▷ Will loss of Antarctic ozone be followed by loss over the rest of the globe? If the explanation involving ice crystals in the polar vortex is correct, then the area suffering ozone destruction is unlikely to widen. Nevertheless, atmospheric mixing processes could reduce ozone levels outside the vortex simply by dilution.

Clearly, we need to advance rapidly to a full understanding of the processes that control the integrity of the ozone layer. Until we do, we cannot be totally confident that our present policies on CFC emissions won't lead to untoward effects. The Antarctic ozone hole has taught us that our understanding of ozone chemistry is lacking, and we'd best act prudently in preserving an unexpectedly fragile ozone layer.

Andrew Bell

More about the topic

Mystery of the Antarctic 'ozone hole'. A. Bell. *Ecos* No. 52, 1987, 7–9.

'Environmental, Health and Economic Implications of the Use of Chlorofluorocarbons as Aerosol Propellants and Possible Substitutes.' Ed. P.J. Fraser. (Australian Environment Council and National Health and Medical Research Council: Canberra 1988.)

Ozone-Friendliness -107

The scientific verdict is now in. Chlorofluorocarbons—chemical compounds that are widely used as refrigerants, cleaning solvents and, in some countries, aerosol propellants—are thinning the ozone layer that shields mankind from dangerous ultraviolet rays. In March, E.I. du Pont de Nemours, the world's largest producer of chlorofluorocarbons (CFC's), announced that it would phase out production of the chemical. (Du Pont invented CFC's in the early 1930s and sells them under the brand name Freon.) In May, Dow Chemical Co. announced that it would phase out the use of fully halogenated CFC's in its Styrofoam insulation and all other products that contain them. It will replace CFC's with compounds less destructive to the atmosphere—as they become available.

Du Pont has been searching for alternatives to CFC's for a few years and has already developed substitutes for some applications, including blowing agents (similar to a gas propellant) for food packaging and new cleaning solvents. The company hopes to have a new refrigerant within five years. And while du Pont, Dow and other chemical giants are trying to tackle the problem, a little-known Norwegian company recently announced that it is making the world's first ozone-friendly insulation panels. Jackon A/S of Fredrikstad says that its insulation plates—which are used under roadbeds and in soccer arenas to protect against ground frost—are manufactured without using CFC's or other harmful cold gases.

The panels are made from polystyrene plastic that is fluffed by a chemical blowing agent. Stein Dietrichson, an engineer at Jackon, would not name the gas, calling it a business secret. But he says it is not destructive to the atmosphere. The panels, which are now commercially available, cost about 8 percent more than Freon panels, or between $7.80 and $12.50 per cubic meter.

Now that CFC's days as a coolant are numbered, the race to develop a new refrigeration technology—for air conditioners, freezers and the like—has begun. Already, a small Pennsylvania company is close to building a prototype of a new thermal automotive air conditioner in which hydrogen (rather than the fluorine featured in Freon) is the working fluid. Hydrogen, which is one of the constituents of air, poses no atmospheric hazard when it is released. Designed by Advanced Materials Corp. of Pittsburgh, in which the Carnegie Mellon University has an academic as well as equity interest, the system features two metal "sponges"—actually nickel-alloy heat exchangers—one of which has a greater affinity for hydrogen then the other. The sponges alternately absorb and then release the hydrogen that is trapped between them. When one of the sponges releases hydrogen, it becomes a cold bed of metal that can chill the air that passes through it, thus producing refrigeration.

Edward Wallace, president of Advanced Products, says the technology is "promising and pretty far along." The principle is not new, he admits; what is new is the design and composition of the heat exchangers. "Any source of heat will drive the system," says Wallace, including automotive or airplane exhaust. He acknowledges that the air conditioner will be bigger and more expensive than current car units, but should also use less gasoline.

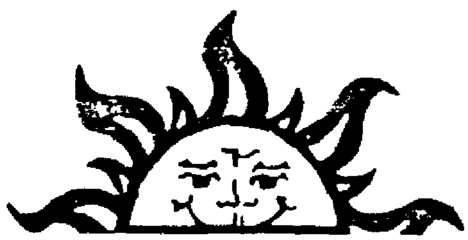
COURTESY DU PONT

Searching for CFC substitutes: *A du Pont Freon manufacturing plant*

RICHARD ERNSBERGER JR.

No 24

Between the Issues Vol. V No. 6
Nov./Dec. 1987



HOPE FOR THE OZONE LAYER?

by Wayne Hall

A worldwide effort to protect the ozone layer passed its first milestone in Montreal. The Protocol on Substances that Deplete the Ozone Layer was signed by over 40 countries on September 16.

The Protocol is the result of over 5 years of negotiations coordinated by the United Nations Environment Programme (UNEP). Initially, the Montreal Protocol will freeze production & consumption of chloroflurocarbons (CFC'S) and halons at 1986 levels. By 1993, consumption will be reduced 20% and, five years later, by an additional 30%.

Specifically, the Montreal Protocol proposes to:

•*freeze* worldwide Chlorofloro-carbon (CFC) production at 1986 levels & reduce atmospheric emissions by 50% by 1999,

•provide for trade sanctions against countries who are not party to the Protocol or who try to undermine its force,

•encourage government & industry cooperation in developing environmentally safe alternative chemicals & technologies,

•provide developing countries with CFC's in vital areas such as refrigeration until alternatives are available.

The Protocol was signed at the time by Canada, the U.S., the 12-member European Economic Community (EEC), and 22 other countries. Other nations —including the Soviet Union—announced their intention to follow suit.

The U.S. and Canada are responsible for 37% of world CFC production according to 1985 industry figures, Europe, the Middle East and Africa for 43%, Latin America 3% and Japan with other Asian and Pacific nations 17%.

Scientists have known about the depletion of the ozone layer since the early 1970s. CFC's are widely used as refrigerants, in plastic foam, to clean computer components, and—except in the U.S., Canada and Scandinavia—as aerosol propellants. Halons, used to extinguish fires, are less widely used but regarded as potentially 10 times more destructive.

At current rates, nearly 1 million tons of CFC's float into the atmosphere every year. They can be active for more than 100 years, which means that all CFC's ever released are still in the atmosphere, where they can destroy fragile ozone molecules for the next 100 years.

Conserving the ozone layer is a classic example of the "tragedy of the commons" dilemma. If one nation unilaterally bans production of harmful substances to protect the environment ("the commons") then everyone everywhere benefits to a certain extent. However, the burden of doing so is borne by the producers of one country and producers in other nations are still free to do as they please. Thus there is a strong incentive to implement an international agreement to reduce the production of CFC's and halons. From this point of view, the Montreal Protocol is indeed "an historic step".

It's clear though, that our governments have not yet taken a close look at the costs of the depletion of the ozone layer. The increases in skin cancer, damage to crops, forests and wildlife resulting from CFC emissions will soon translate into an economic loss to the world in the trillions of dollars—a stupid, senseless waste that could have been prevented fifteen years ago. It was only the discovery of holes in the ozone over the Antarctic and Greenland in 1985 that spurred nations to the bargaining table.

Unfortunately, last-minute compromises made to reach an agreement have raised serious doubts about the willingness of some countries to enforce its provisions. Despite a truly impressive international effort, the Protocol falls far short of the 85% cut—within two years—in emissions which scientists are calling for just to stabilize CFC levels.

The U.S. and Canada have led the way in responsible CFC use, banning their use in aerosol propellants in the early 1970's. U.S. environmentalists have applauded the EPA's contribution to the Protocol despite the strongly anti-environmentalist stance of the White House. The U.S. Sierra Club is calling it the greatest environmental achievement of the Reagan Administration, though they admit there's not much to compare it with.

The U.S. was one of the main proponents of this treaty—originally calling for a 95% reduction by 1995. Fear of the talks collapsing resulted in the target goal being reduced to 50%—"a more realistic target".

Now, if we could just get together on this nuclear weapons thing.

NOTE:
There will be a conference in Washington, DC, on Substitutes and Alternatives to CFC's and Halons January 13-15 1988 which will be co-sponsored by the Conservation Foundation, U.S. EPA and Environment Canada.