C759 CC429 Walter Orr Roberts (Walt R.,759) 7/12/86 6:25 PM L:112
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Memo to: The Climate Club -- C759 12 July 1986
From: Walt Roberts

Provocation No.113
Depleting the Ozone Layer

The ozone layer reaches maximum concentration in the stratosphere some 25 kms above our heads. It is essential to all life on earth. Though present only in trace amounts, ozone shields all living things from otherwise fatal doses of solar ultraviolet light. Even relatively small reductions in the ozone layer, studies show, can increase significantly the rate of skin cancers in humans. A 1% reduction in ozone is estimated to produce a 2% average increase in solar ultraviolet radiation at the ground. Reduced stratospheric ozone has other adverse effects as well, for example on some kinds of vegetation, and also adds slightly to the "greenhouse warming" effect on climate.

Changes occurring in the ozone layer have been the subject of uncertainty and controversy ever since 1970 when Johnston and Crutzen described hazards from supersonic transport aircraft fleets. This intensified in 1974 when Rowland and Molina announced the threat to the layer from the release of chlorofluorocarbons (CFC's) to the atmosphere from industrial sources.

The role of the ozone layer in screening out harmful solar ultraviolet has long been known. We understand pretty well the basic atmospheric chemistry leading to ozone formation by sunlight and its destruction by a combination of sunlight and chemical reactions, both occurring high up in the atmosphere. There are substantial uncertainties, however, about exactly how production and destruction balance out. Moreover, we do not know nearly well enough the effect that man-made gases have on the ozone layer. CFC's are very long-lived in the atmosphere, and they migrate slowly up to the ozone layer to perhaps 40 kms, where they are finally destroyed by photochemical reactions that produce chlorine in the process. The chlorine and its oxides, in turn, destroy ozone. Incidentally, there is also a lot of ozone produced near the earth's surface in large urban areas like Los Angeles, but that is a totally different story, unrelated to stratospheric ozone.

When a supersonic aircraft (SST) fleet was first being talked about as a passenger travel system by the US, the USSR, and the British-French consortium the worry was about the possible depletion of stratospheric ozone layer by nitric oxides in jet exhausts at the higher levels at which SST's cruise. Some scientists opposed the SST on grounds of this danger. Others, aware of the uncertainties about the chemistry involved, felt on balance that an SST fleet might be no more destructive to climate or health than the sub-sonic jumbo jets, like the 747's and other big jet fleets now flying the world, which can alter cirrus cloud patterns. I found myself in this camp, and so testified before the Congress during the SST debates. The British-French group proceeded to build the Concorde fleet. The Soviets made prototypes, including the ill-fated SST that crashed at the Paris air show, and then abandoned the project. For economic reasons, the US never built its passenger SST, though it had some very advanced features. We now think the prime threat to ozone is CFC's, and not the SST.

Since 1974, when the possible CFC threat to ozone was first recognized, no firm positions have been taken by the Environmental Protection Agency (EPA) in this country or by other governments on the manufacture of CFC's.

Responding to public pressure, industry in this country stopped using them for propellant in aerosol spray cans, but they continue in functions like the coolant in refrigeration and the foaming agent in manufacture of plastic foam insulation. Every year more than a billion dollars worth of CFC's are produced, worldwide. All of this CFC, ultimately, leaks to the atmosphere. Because of its hundred year average life there as a non-reactive gas, it mixes slowly to the ozone layer, the main "sink" for CFC's. Chlorine compounds released in the decomposition of the CFC's, atmospheric chemists think, is the culprit in stratospheric ozone reductions.

Research continues as we study how and at what rates the CCF's interact with the ozone layer. The many chemical reactions involved are fiendishly complicated, partly because of surface chemistry effects on atmospheric particles. Processes appropriate to the stratosphere are hard to study in the lab. Moreover we are not sure what processes may have been ignored in our researches, yet be important in the real ozone layer. Nor are we sure of the interactions of other atmospheric gases that are also changing in concentration, such as carbon dioxide, methane and the like. The original findings of Rowland and Molina, alarming in their magnitude, were first revised downwards, then part way upwards again. Chemical industry leaders maintain that if and when a real threat is discovered they will stop producing CFC's, but insist that bans are unwarranted at this time. So far they have largely prevailed. Meanwhile, the CFC content of the atmosphere has almost doubled over the last decade.

Now, an enigma confronts us. Satellite data reveal a huge decrease in the ozone over the Antarctic. It is enough to be very alarming. At first the sketchy satellite results were considered wrong, so large were the declines. The data were simply attributed to instrumental errors. Now, backed up by ground-based measurements, we find it inescapable that there is an ozone "hole" over the Antarctic, where the ozone concentration is less than half of normal. Also a smaller but significant decrease has perhaps occurred world-wide as well. Some scientists speculate that CFC's are not the sole cause--it may also be El Chichon volcanic ejecta, or even changes in high level wind circulation systems. But most of the still-uncertain evidence fingers chlorine compounds, and identifies the CFC's as their major source.

Existing theories do not predict so large a decrease as we now observe over the Antarctic. Moreover, the latest National Academy of Sciences report warns that if we continue the present CFC usage, the total ozone layer will eventually decline leading to an average increase of perhaps 10% in solar ultraviolet at the ground. This is sufficient to be a significant health risk. I think the Antarctic data may be telling us that the ozone decrease may be even larger than we thought. In any case, we confront a science policy issue with big global consequences, but also an issue fraught with uncertainty.

Do we consider a strongly suspect man-made gas innocent of damage to nature until proven guilty--when it may take so long to do the definitive research that it will then be too late to stop its effects for many decades? How serious do we consider a 10% increase in solar ultraviolet? Congress, the EPA, the United Nations Environment Programme and other governments are now contemplating stronger measures to institute control over production of CFC's. Will they be too little, too late? What will human societies ultimately have to pay for so long incurring an avoidable risk?

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(Apologies for the length!!)