HISTORY OF THE OZONE DEPLETION SCARE

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Supplementary Material for " An Empirical Test of the Chemical Theory of Ozone Depletion"[1]
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1. PRIOR TO FARMAN ET AL 1985[2]

1969: The SST: A plan to develop high altitude supersonic airliners with the Boeing 2707 as a concept vehicle. The very high cruising altitude of the SST raised environmental alarms that included both climate change and ozone depletion.

1969: Climate change: An alarm is raised that chemicals and aerosols in the exhaust of the SST jet engines will cause climate change.

1970: Ozone depletion: The climate change theory is quietly shelved after critical reviews by skeptics and a new alarm is raised. Water vapor in the SST jet exhaust will cause a 4% depletion of ozone in the ozone layer causing 40,000 additional cases of skin cancer every year in the USA alone.

1970: Ozone depletion: The water vapor theory is quietly forgotten after critical reviews by skeptics who produced data showing that higher levels of water in the stratosphere is coincident with higher levels of ozone.

1970: Ozone depletion: A new ozone depletion theory emerges. Nitric oxide (NOx) in the SST jet exhaust will cause ozone depletion because NOx acts as a catalyst to destroy ozone without being consumed in the process.

1971: Ozone depletion: A computer model is developed to assess the impact of NOx in SST exhaust on the ozone layer. The model predicts that there will be a 50% ozone depletion and a worldwide epidemic of skin cancer. Animals that venture out during daylight will become blinded by UV radiation. It was an apocalyptic scenario.

1971: Ozone depletion: NOx in the fireball of open air nuclear tests provide a ready laboratory to test the ozone depletion properties of NOx. The computer model predicted 10% ozone depletion by NOx from nuclear testing. Measurements showed no ozone depletion; but the model won anyway and the ozone depletion scare endured.

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[1] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2719537

[2] Farman, J. (1985). Large losses of total ozone in Antarctica reveal seasonal ClOx/NOx interaction. Nature , 315.207-210.

1972: Death of the SST: We were so frightened by the ozone depletion scare that the SST program was canceled although America's skies soon became filled with supersonic fighters and bombers spewing NOx without any evidence of ozone depletion or of skin cancer or of blindness in animals.

1972: Nuclear summer: Although not confirmed by the data, ozone depletion by nuclear bombs predicted by the computer model took on a life of its own and morphed into a new catastrophe theory called the nuclear summer.

1972: Nuclear summer: The phrase "nuclear summer" is everywhere in the media. There is a doomsday forecast that the immediate result of a nuclear war will be the total annihilation of the ozone layer. All life on earth will be wiped out by UV radiation. Therefore there can be no winner or loser in a nuclear exchange of sufficient intensity. Mutual destruction is assured.

1973: Nuclear summer: Report by the National Academy of Science: An exchange of thousands of megatons of nuclear bombs will increase NOx in the stratosphere by an order of magnitude. The NOx will destroy 30%-70% of the ozone in the northern hemisphere and 20%-40% of ozone in the southern hemisphere. Within a few months we will be blinded and roasted by UV radiation with blistering of the skin. The atmosphere will take 30 years to recover. All of these findings were derived from a sophisticated computer model and these findings were supported by a broad consensus of scientists.

1973: Nuclear summer: Skeptics of the ozone scare point out that the study of nuclear testing did not show any ozone depletion and also that vast amounts of NOx – more than man could ever inject into the stratosphere – is made by nature when solar wind strikes nitrogen in the atmosphere; and therefore that there must be something wrong with the computer model that causes it to over-estimate the effect of NOx on ozone.

1973: Space Shuttle: Unperturbed by the skeptics and emboldened by their SST success, fear mongering scientists turn their attention to the proposed Space Shuttle program. The shuttle design included two solid fuel rockets that emit hydrogen chloride (HCl). Scientists calculated that 50 flights per year would deposit 5000 tons of HCl per year in the stratosphere that could cause a 10% ozone depletion over Florida and 1% to 2% elsewhere. Although the scare was hyped it never got to the SST levels and the space shuttle miraculously survived the ozone scare.

1974: Ozone depletion: The ozone depletion game was now in full gear. Having tasted the power of being able to inflict debilitating fear of ozone depletion, the scientists embarked on a fishing expedition to find other chemicals generated by human activity that could get up to the stratosphere and catalyze the chemical reactions of ozone depletion.

1974: CFC: A new candidate agent for ozone depletion is found. Chlorofluorocarbons are synthetic chemicals used in aerosol sprays and in refrigerant for air conditioners and refrigerators. CFC emissions to the atmosphere accumulate in the stratosphere because there are no sinks to remove them from the

lower atmosphere. Up in the stratosphere they are able to catalyze the destruction of ozone. The ozone depletion game was thus begun anew.

1974: Doomsday Theory: When CFCs rise to the stratosphere they are decomposed by UV radiation to release chlorine. The chlorine ion can then catalyze thousands of ozone destruction cycles without being consumed. Up to 40% of the ozone will be destroyed. The chlorine theory was old but its ready supply from CFCs was a completely new angle and so a new doomsday scenario was quickly sketched out for dissemination. NY Times, September 26,

1974: A big day for Doomsday journalism. The NYT predicts ozone depletion of 18% by 1990 and 50% by 2030 by CFCs will cause an epidemic of skin cancer, mutation of frogs, and blindness in animals and humans. The whole world is frightened. The ozone scare had begun anew this time with CFC as the agent of ozone depletion. The scare was very successful and it appeared in various forms almost every day in newspapers and on television for the next two decades.

2. AFTER FARMAN ET AL 1985

March 10, 1987: Skin cancer is increasing in the United States at ``a near epidemic rate,`` outstripping predictions made as recently as five years ago, a research physician testified Monday before a House panel examining threats to the Earth's protective ozone layer. Malignant melanoma, the deadliest form of skin cancer, ``has increased 83 percent in the last seven years alone,`` he said. ``Melanoma is increasing faster than any other cancer except lung cancer in women.`

March 12, 1987: If the harmful radiation reached the Earth, it would cause monumental problems, including rampant skin cancer and eye cataracts, retarded crop growth, impairment of the human immune system and damaging radiation doses to all forms of life. Although many Americans and the people of other nations are still not listening or taking the ozone threat seriously, the Earth's protective shield is getting thinner and developing mysterious holes. There is a growing consensus among scientists that ozone destruction is caused by the accumulation in the upper atmosphere of chlorofluorocarbons (CFCs), a class of industrial chemicals used for refrigerants, aerosols, insulation, foam packaging and other uses.

August 23, 1987: Scientists have begun the largest study ever of the depletion of the ozone layer in the atmosphere by sending a modified spy plane on missions 12 1/2 miles above Antarctica. The flights this past week were part of a $10-million project being carried out by a 120-member team of scientists, engineers and technicians who hope to decipher a mysterious ``ozone hole`` that has been detected over Antarctic each winter for the past eight years.

September 24, 1987: Sometimes when the world seems bent on self-destruction, a ray of hope pierces the darkness. A historic first international agreement to protect the Earth's ozone layer inspires that kind of encouragement. Twenty-four nations plus the European Community signed the Montreal

Protocol to reduce production of synthetic chemicals that float to the stratosphere and erode the ozone layer, the invisible shield that filters out the sun's harmful ultraviolet rays. The world's leading scientists have warned that the continuing destruction of ozone by man-made chemicals would cause sharp increases in skin cancer and cataracts, damage crops, forests and marine life and cause other environmental changes.

October 1, 1987: Ozone levels above Antarctica reached an all-time low since measurements began and scientists said Wednesday that they found strong evidence indicating that man-made Freon-type gases are to blame. Ozone is the only gas in the atmosphere that filters out harmful amounts of ultraviolet radiation from the sun. Estimates endorsed by the Environmental Protection Agency say that for every 1 percent of ozone decrease in the global atmosphere, there could be 20,000 more skin cancer cases annually in the United States.

November 27, 1987: The hole in the ozone radiation shield over Antarctica is caused by chlorine from gases used for years as propellants in spray cans, scientists confirmed Thursday. The chemical reaction that causes the depletion is possible only in the presence of polar clouds - composed of tiny ice crystals - and the amount of sunlight that reaches the South Pole in late winter and early spring, scientists wrote. ``It's only recently we began looking at ice particles as possible participants,`` said Mario Molina, an atmospheric chemist at the California Institute of Technology's Jet Propulsion Laboratory in Pasadena.

December 20, 1987: The frigid air over Antarctica took three weeks longer than usual to warm at the onset of the Antarctic spring this year, prompting concern that the ``ozone hole`` discovered over the icy continent less than three years ago may be affecting global climate. According to satellite data from the National Aeronautics and Space Administration (NASA), the polar vortex - a whirlpool-like mass of extremely cold air that forms over Antarctica in the dark winter months - broke up in late November. The vortex normally breaks up in late October or early November, when spring brings sunlight back to the South Pole and warms the atmosphere.

February 7, 1988: Global warming and further deterioration of the upper atmosphere's protective ozone layer can be expected to accelerate the formation of smog in major cities across the United States, a new study for the U.S. Environmental Protection Agency (EPA) has found. Based on a year-long examination, researchers said that smog would be formed earlier in the day under conditions of global warming and a depleted upper atmospheric ozone shield. In the most polluted cities, the global effects would also increase maximum ground level ozone concentrations.

March 4, 1988: The amount of methane gas in the atmosphere has risen 11 percent since 1978, possibly speeding the seasonal loss of protective ozone above Antarctica but blocking the same depletion over the rest of the Earth, researchers say. ``We're changing the atmosphere in a rather rapid way. It's hard to tell what the eventual consequences will be, but there are several ways it may have a strong impact on man,`` said Sherwood Rowland, a chemist at the University of California, Irvine (UCI), whose study was published today in the journal Science.

September 21, 1988: Earth's protective ozone layer will continue to be eroded by chlorine even if ozone-depleting chemicals known as chlorofluorcarbons (CFCs) are phased out, an environmental group said Tuesday. But the Environmental Policy Institute concluded in a report that if two other chlorine-producing compounds - methyl chloroform and carbon tetrachloride - were also eliminated, the amount of chlorine in the atmosphere could decline significantly over the next three decades.

December 4, 1988: Earth's protective ozone is thinning more than expected in northern regions of the globe, say scientists who detailed Tuesday an intense research effort to try to find out the reasons why. While the so-called ozone hole over the South Pole has attracted the most media attention, a lesser but still significant thinning also has been found in the North.

February 3, 1989: Scientists working in the Northwest Territories fear that serious damage to the ozone layer over the Arctic Ocean is imminent, a senior official said Thursday. Wayne Evans, experimental studies chief for Environment Canada, said its High Arctic weather team has discovered the presence of dense ice clouds similar to those that have helped cause a huge hole in the ozone over Antarctica.

February 18, 1989: Earth's protective ozone layer seems to have broken down over the Arctic, a team of international scientists said Friday. They said it is not yet clear to what extent pollution may be to blame. About 150 scientists from various countries have been investigating the ozone layer for six weeks from a base in Stavanger on Norway's west coast. The ozone layer is important because it filters out harmful solar rays. If ozone levels are significantly reduced, scientists say, it could lead to an increase in some skin cancers, crop failures and damage to marine life.

March 21, 1989: Humankind has suddenly entered into a brand new relationship with our planet. Unless we quickly and profoundly change the course of our civilization, we face an immediate and grave danger of destroying the worldwide ecological system that sustains life as we know it. In 1939, as clouds of war gathered over Europe, many refused to recognize what was about to happen. No one could imagine a Holocaust, even after shattered glass had filled the streets on Kristallnacht. World leaders waffled and waited, hoping that Hitler was not what he seemed, that world war could be avoided. Later, when aerial photographs revealed death camps, many pretended not to see. Today, clouds of a different sort signal an environmental holocaust without precedent. Once again, world leaders waffle, hoping the danger will dissipate. Yet today the evidence is as clear as the sounds of glass shattering in Berlin.

September 24, 1989: A hole has opened in the atmosphere's ozone shield above Antarctica, and scientists say it is growing at the same rate as the one in 1987 which broke records. Ozone in the earth's stratosphere normally blocks most ultraviolet radiation from the sun, shielding people and wildlife from harmful radiation effects. But certain chemicals released into the air - chlorofluorocarbons used in refrigerators, air conditioners, and spray cans - are destroying ozone. Scientists fear an epidemic of skin cancer and other radiation-induced diseases will result.

March 15, 1990: The holes in the world's protective ozone layer will still be there in 2060 and beyond even if governments severely restrict the use of damaging chemicals, the United Nations' leading environmental official said Wednesday.

October 10, 1991: NASA reported Wednesday that a satellite passing over Antarctica had measured the lowest stratospheric ozone level on record, an ominous indication of potential global health risks.

October 24, 1991: The rate of ozone depletion has accelerated and will continue at the higher rate in the 1990s, requiring a more rapid phasing out of chlorofluorocarbons and other manmade chemicals that destroy ozone in the atmosphere.

November 22, 1991: A fleet of planes spraying 50,000 tons of propane or ethane high over the South Pole possibly could neutralize the Antarctic ozone hole, scientists say.

February 4, 1992: Government scientists say they have recorded the highest levels of ozone-damaging chemicals ever measured over the northern hemisphere, making it likely an ozone hole will develop this winter over parts of the United States, Canada and Europe[3]. "Everybody should be alarmed about this," Michael J. Kurylo, manager of the upper atmosphere research program at NASA, said Monday. "We're seeing conditions primed for ozone destruction. It's in a far worse way that we thought." Kurylo said aircraft and satellite instruments have measured levels of chlorine monoxide, a manmade chemical by-product, at up to 1.5 parts per billion, the highest levels ever recorded.

September 6, 1992: As of July 1, 1992 it became illegal to vent refrigerant gases into the atmosphere. These gases contain chlorofluorocarbons, or CFCs, which do the cooling. Scientists believe that CFCs released into the air have been rising into the stratosphere where they have been destroying the earth's protective ozone layer. Ozone helps filter out some of the sun's ultraviolet rays. Those rays cause skin cancer and, because of holes in the ozone layer, health experts expect an extra 12-million cases of skin cancer over the next 50 years.

September 30, 1992: Satellite measurements show the ozone hole over Antarctica is now the largest on record and almost three times larger than the area of the United States, NASA announced Tuesday. The space agency said measurements by the Total Ozone Mapping Spectrometer instrument aboard the Nimbus-7 satellite showed last week the south polar territory under a depleted ozone area of the atmosphere extended for about 8.9-million square miles, about 15 percent larger than the ozone hole measured in 1991. Ozone, composed of three oxygen atoms, is a natural chemical in the atmosphere. It acts as a filter against damaging ultraviolet radiation from the sun. Chemical reactions can destroy ozone by stripping away one atom of oxygen, removing the shielding effect of ozone.

November 1, 1992: The EPA publishes its ozone tutorial as follows: The ozone layer consists of: Free oxygen atom (O), two oxygen atoms making an oxygen molecule (O2), and three oxygen atoms making

[3] The Antarctic ozone hole was feared as a precursor to ozone holes over populated areas.

an ozone molecule (O3). Oxygen molecules are transformed into ozone by the sun's ultraviolet (UV) radiation, which splits the oxygen molecule into two free oxygen atoms. The free oxygen atoms bind to other oxygen molecules forming ozone. The ozone molecules also are broken up by UV radiation, converting it back into one free oxygen atom and one oxygen molecule. This continuous cycle occurs normally in the stratosphere. Once chlorofluorocarbons (CFCs), consisting of atoms of carbon, fluorine and chlorine (CI), reach the ozone layer, UV radiation breaks off an atom of chlorine. A free chlorine atom reacts easily with other molecules. When it collides with an ozone molecule, it can break up the molecule by stripping away an oxygen atom.

November 26, 1992: Future accumulations of a gas that promotes global warming may lead to ozone "holes" over the Arctic similar to those now detected over Antarctica, a study says. The ozone reduction would expose Arctic wildlife to more ultraviolet radiation and might mean transient increased exposures for people elsewhere in the Northern Hemisphere. Ultraviolet radiation promotes skin cancer and cataracts.

November 26, 1992: Spurred by recent evidence that Earth's protective ozone layer is being depleted more extensively than feared, a U.N. environmental conference agreed Wednesday to move up the deadline for eliminating some ozone depleting substances to the end of 1995. Representatives of 87 countries moved up the phase out deadline from the year 2000 to January 1, 1996. The chemicals affected, mainly chlorofluorocarbons or CFCs, are industrial chemicals widely used as refrigerants, solvents and cleaning agents. The delegates set an even earlier deadline of 1994, for chemicals known as halons, which are used in fire extinguishers. The delegates also set a timetable for eliminating hydro-chlorofluorocarbons, or HCFCs. Industry has been relying on these chemicals as interim substitutes for the more potent ozone depleting substances pending the development of permanent substitutes. HCFCs, which still deplete ozone but not as much as the chemicals they replace, are now to be eliminated in stages starting in the year 2004 and ending in 2030.

April 23, 1993: The ozone layer - Earth's protective shield against ultraviolet radiation - has dropped to record-low levels over the Northern Hemisphere, including the United States. A research team reports in today's issue of the journal Science that the 1991 eruption of Mount Pinatubo in the Philippines may have accelerated ozone depletion. Scientists said one of the ways the volcano could have contributed to the lower ozone levels is by its release of microscopic dust particles into the upper atmosphere. The losses, expected to persist into summer, include an average drop of 12 percent over the mid-latitudes where most Americans, Canadians and Europeans live, and a dip of 15 percent over the West Coast, including California. Ozone is down by as much as 20 percent over Northern Canada, Greenland, Norway, parts of Alaska and Siberia.

September 24, 1993: Calling the drop in atmospheric ozone "an unprecedented decrease," the National Oceanic and Atmospheric Administration said the ozone appears to have been gobbled up by chemical reactions involving manmade chlorine compounds and an enormous blast of dust from the Mount Pinatubo volcano in the Philippines.

October 19, 1993: Ozone levels over the Antarctic have dropped to record lows over the past month, creating a polar "ozone hole" bigger than Europe, the World Meteorological Organization (WMO) said late last week. The United Nations agency said levels of the gas over the southern pole had regularly fallen below 100 Dobson units, "representing the lowest absolute daily minimum ever recorded in the history of ozone observations." & "It's the worst we've seen yet," WMO ozone expert Rumen Bojkov told Reuters. "It is lower now than we had thought was possible."

August 27, 1994: The protective ozone layer over North America has rebounded from its extremely low level of two winters ago, but that doesn't mean it's time to relax. High-altitude "ozone over the U.S. during the winter of 1993-1994 recovered from the record low values of the previous winter," a team of scientists reports in Geophysical Research Letters. Ozone levels that were as much as 15 percent below normal in 1992-1993 have risen to slightly above normal. The layer of ozone high in the atmosphere helps block dangerous ultraviolet radiation from the sun. Too much of this radiation can lead to skin cancer, premature aging of the skin and eye damage.

December 21, 1994: Three years of data from a NASA satellite have provided conclusive evidence that man-made chlorine in the stratosphere is the primary cause of the ozone hole above Antarctica, scientists said this week. "The detection of stratospheric fluorine gases, which are not natural, eliminates the possibility that chlorine from volcanic eruptions or some other natural source is responsible for the ozone hole," NASA's Mark Schoeberl said Monday.

October 30, 2000: This year the ozone hole over Antarctica has reached its lowest level since scientists began these measurements. According to the U.N. World Meteorological Organization, monitoring stations around have reported ozone measurements that are 50 percent to 70 percent below the norms 30 years ago.

December 7, 2005: Current computer models suggest the ozone hole should recover globally by 2040 or 2050, but Tuesday's analysis suggests the hole won't heal until about 2065.

April 5, 2011: The WMO reports as follows: Depletion of the ozone layer- the shield that protects life on Earth from harmful levels of ultraviolet rays - has reached an unprecedented level over the Arctic this spring because of the continuing presence of ozone-depleting substances in the atmosphere and a very cold winter in the stratosphere. The stratosphere is the second major layer of the Earth’s atmosphere, just above the troposphere. The record loss is despite an international agreement which has been very successful in cutting production and consumption of ozone destroying chemicals. Because of the long atmospheric lifetimes of these compounds it *will take several decades before their concentrations are back down to pre-1980 levels*, the target agreed in the Montreal Protocol on Substances that Deplete the Ozone Layer.

May 19, 2015: NASA declares that the ozone depletion problem has been solved by the Montreal Protocol's global ban on ozone depleting substances.
https://www.youtube.com/watch?v=FXQUMg3Cgrs