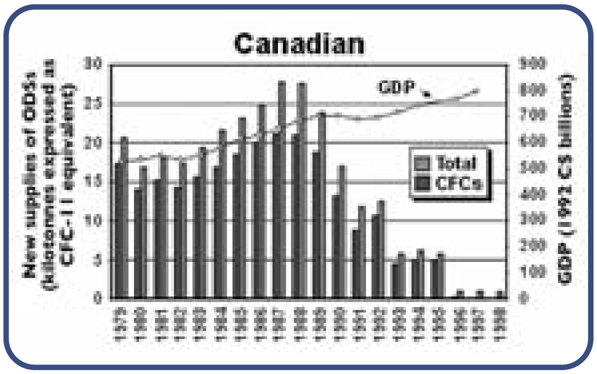
bulletin
of the northern climate exchange · 6

Climate change, the ozone layer, and chlorofluorocarbons

One of the environmental stories that has grabbed headlines over the past 20 years is the “hole in the ozone layer.” Human-made chemicals have been breaking down the ozone layer over the entire globe. Because of cold temperatures and lack of sunlight, the problem is most pronounced over the North and South poles during spring. This bulletin examines damage to the ozone layer and the efforts being made to improve the situation.



Graph Source: Environment Canada, http://www.ec.gc.ca/soer-ree/English/Indicators/Issues/Ozone/Bulletin/st_iss_e.cfm

In the Arctic, snow cover can double UV-exposure.

Arctic Monitoring and Assessment Programme 1997

The ozone layer

Ozone (O_3) is a gas present in small quantities in our atmosphere. Most of the atmosphere’s ozone is found in the stratosphere. The stratosphere is the layer of the atmosphere found 10 to 50 kilometres above the earth’s surface. The lower boundary varies from as low as 8 kilometres at the poles to as high as 17 kilometres at the equator. Ozone is found throughout this layer.

To give an idea of how scarce ozone is, for every 10 million molecules of air in our atmosphere, there is an average of 3 molecules of ozone. If all the ozone in the atmosphere was brought together at the earth’s surface, it would form a layer only one-eighth of an inch thick.

Ozone in the atmosphere is constantly being created and destroyed naturally. Solar radiation interacts with oxygen in the upper atmosphere to create ozone while natural compounds containing nitrogen, hydrogen and chlorine destroy it. This natural system had been in balance until human-introduced chemicals began to destroy ozone.

Why is ozone important?

The sun sends out a stream of radiation at different wavelengths. The visible light spectrum, so vital to all life on earth, is just a small part of the total stream of radiation that the earth is constantly bombarded with. We also receive ultraviolet radiation from the sun. Ultraviolet (UV) radiation is divided into three categories. UV-A radiation is not blocked by the atmosphere and is in fact needed by humans to produce vitamin D in the body. UV-C radiation is completely blocked by stratospheric ozone.

The problem arises with UV-B radiation. Experts calculate that for each one percent decrease in stratospheric ozone content of the atmosphere, the amount of UV-B radiation reaching the earth’s surface increases by 1.5% to 2%. In humans, excessive exposure to UV-B radiation can cause sunburn, skin cancer, and cataracts. The United States Government’s Environmental Protection Agency estimates that a 2% increase in UV-B radiation would result in a 2% to 6% increase in the incidence of non-melanoma skin cancer.

There are also negative effects to portions of our ecosystem. Zooplankton and phytoplankton in the world’s oceans are also sensitive to UV radiation. These organisms are important because they form the base of the ocean’s food web.

Scientist have also speculated that increases in UV radiation negatively affect frog’s eggs. Inuit hunters are questioning whether symptoms they are noting on seals and other Arctic animals are related to increasing UV levels.

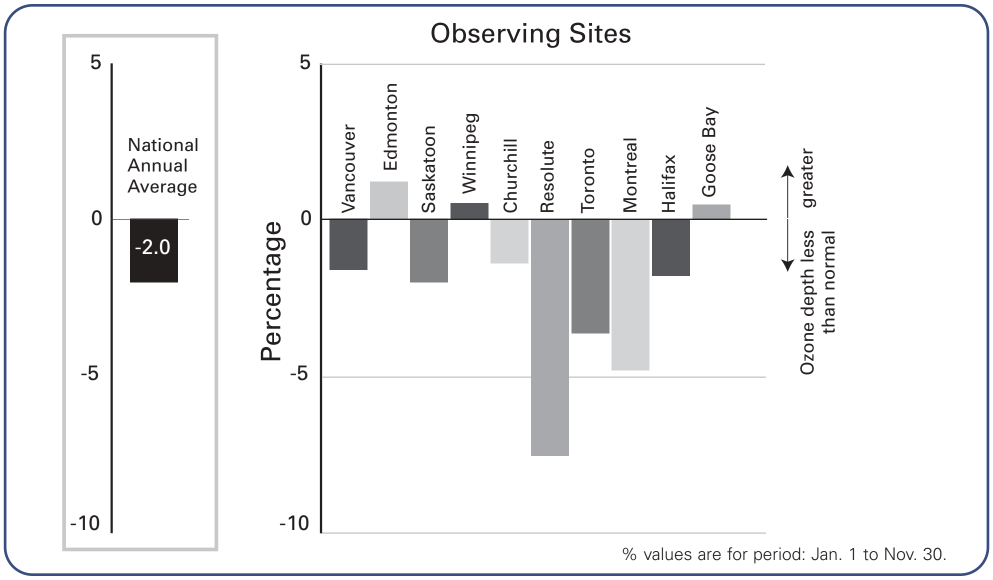
What’s causing ozone depletion?

Ozone depletion is caused by our use of chlorofluorocarbons(CFCs). This class of chemicals was developed in the 1930s. Because of their chemical properties, CFCs have been used for a number of purposes. They have been used as refrigerants and as propellants in aerosol cans for such things as hair spray, insect repellent, and spray paint. Electronics manufacturers used CFCs as cleaning solvents for circuit boards and other electronic components. CFCs have also been used in fire extinguishing systems.

Yukon College
Yukon Government
Canada

Ozone and polar regions

In polar regions, ozone levels can decrease rapidly during polar spring. After months of darkness and cold temperatures, the return of sunlight provides ideal conditions for the breakdown of ozone. This is what causes the "ozone hole" over the Antarctic and Arctic. The decrease in ozone over the Antarctic was first noted in 1985 and has been monitored since. In 1998, the hole that developed over Antarctic regions covered an area of some 26 million square kilometres. A smaller hole has developed intermittently over the Arctic since the late 1980s, typically causing a reduction of 20% to 25% in ozone levels.



State of Canada's ozone layer – annual averages

Graph Source: Environment Canada, National Environmental Indicator Series, Stratospheric Ozone Depletion

What's being done?

Once there was a realization that CFCs were destroying the ozone layer, international action was taken. The United Nations started a discussion of ways of reducing the production of CFCs and other ozone-destroying substances. These negotiations resulted in the signing of the Montreal Protocol on Substances that Deplete the Ozone Layer on September 6, 1987. That protocol set a schedule for eliminating the use of most CFCs. Worldwide production of most CFCs has decreased dramatically since the Montreal protocol was signed. Production of CFC-11 and CFC-12, two of the most widely used CFCs, dropped 96% and 92%, respectively.

Does this mean the problem is over?

Even though we are in the process of eliminating the use of CFCs, depletion of the ozone layer will continue to be a problem because these chemicals have long lives. The atmospheric lifetime of CFC-11 is 45 years, while the lifetime of CFC-12 is 100 years. The most-used replacement chemical, HFC-134a, has an atmospheric lifetime of approximately 14 years.

Ground-level ozone

Ground-level ozone is mainly a big city problem. It forms during warm summer conditions in large urban centres. Vehicle exhaust, industrial emissions, and particulate matter combine with ground-level ozone to form smog. Smog contains nitrogen oxides, volatile organics, and sulphur oxides, which can aggravate conditions such as asthma and emphysema.

Greenhouse gases and ozone destruction

Until very recently, scientists had not established any links between greenhouse gases and ozone destruction. However, a 2002 study by National Aeronautic and Space Agency (NASA) scientists found that by the 2030s, climate change may surpass chlorofluorocarbons as the main driver of overall ozone loss due to increased temperatures and moisture content in the lower stratosphere. Their computer simulations suggest that climate change from greenhouse gases may greatly slow any anticipated ozone recovery due to the elimination of CFCs.

Using computer models that isolated the impacts of CFCs on ozone, they predict that as CFCs decline, by the year 2040 overall ozone makes close to a full recovery from current low levels. When CFCs, water vapour, and temperature changes were all combined in a computer model, by 2040 overall ozone levels recovered only slightly from their current low point.

Source: U.S. Environmental Protection Agency Ozone depletion website: www.epa.gov/ozone/geninfo/gwps.html

Additional reading

To view current ozone levels over Canada
http://exp-studies.tor.ec.gc.ca/e/ozone/Curr_map.htm

Environment Canada Ozone site
http://www.ec.gc.ca/ozone/en/index.cfm

Smog and health
http://www.aqmd.gov/smog/inhealth.html

The National Academy of Sciences: The Ozone Depletion Phenomenon
http://www.beyonddiscovery.org/content/view.article.asp?a=73

University of Cambridge Centre for Atmospheric Science: The Ozone Hole Tour
http://www.atm.ch.cam.ac.uk/tour/

NASA: Stratospheric Ozone Depletion
http://www.nas.nasa.gov/About/Education/Ozone/

Arctic Monitoring and Assessment Program
http://www.amap.no/