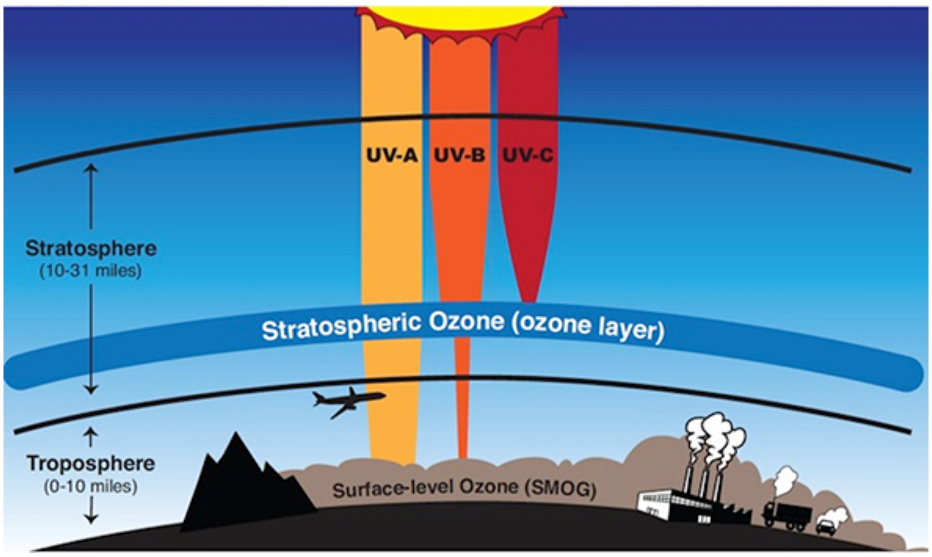
The Ozone Layer

Near the ground, ozone is an air pollutant that causes lung damage and asthma attacks. But 10 to 30 miles above the Earth's surface (16-48 km), ozone molecules protect life on Earth. They help shield our planet from harmful solar radiation.

The ozone layer, in the **stratosphere**, is where about 90% of the ozone in the Earth system is found. But ozone makes up only one to ten out of every million molecules in the ozone layer. (The rest of the molecules are mostly nitrogen and oxygen, like the air we breathe.) There isn't much of it, but **ozone** is powerful, able to block the most harmful radiation.

Ozone absorbs the most energetic wavelengths of **ultraviolet light**, known as UV-C and UV-B, wavelengths that harm living things. Oxygen molecules absorb other forms of ultraviolet light, too. Together, **ozone** and **oxygen molecules** are able to absorb 95 to 99.9% of the ultraviolet radiation that gets to our planet. When UV light is absorbed by oxygen and ozone, heat is generated, which is why the stratosphere gets warmer with altitude.



The ozone layer in the stratosphere shields life on Earth from most UV-B and UV-C, the most harmful varieties of ultraviolet radiation.
Credit: NASA

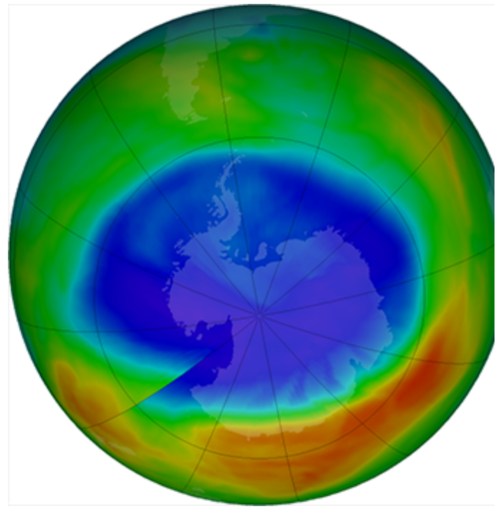
Ozone and oxygen molecules are constantly being formed, destroyed, and reformed in the ozone layer as they are bombarded by ultraviolet radiation (UV), which breaks the bonds between atoms, creating free oxygen atoms. Free oxygen atoms are highly reactive, meaning that they bond easily with other molecules. If a free oxygen atom bumps into an oxygen molecule (O_2), it will form ozone (O_3). If a free oxygen atom bumps into another oxygen atom, it will form an oxygen molecule (O_2).

Ozone Holes

British scientists at Halley Bay, Antarctica, thought their instruments were malfunctioning when they started recording low ozone amounts in the ozone layer above Antarctica in 1976. They had been measuring ozone in the Antarctic atmosphere since 1957 and had never before seen the levels drop so much. Why would ozone levels have dropped? Could it just be natural variation?

They detected a 10% drop in ozone levels during September, October, and November—the Antarctic spring. Since ozone concentrations over this region often vary from season to season, the researchers weren't concerned, but record low ozone levels kept occurring nearly every spring. No one knew why.

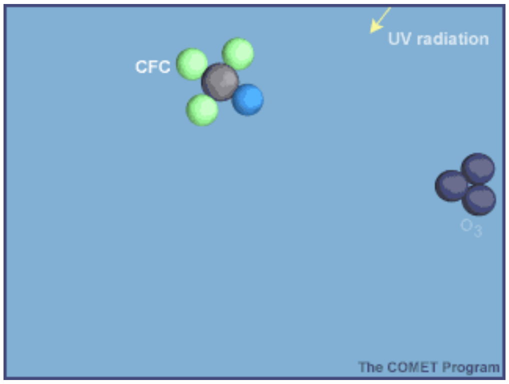
They were the first to find an ozone hole and it would later be identified as the world's largest ozone hole. An ozone hole is really not a hole but rather a thinning of the ozone layer in the stratosphere that changes seasonally. At some times of year the "hole" is larger. At other times, it's smaller.



In 2017 the ozone hole over Antarctica was the smallest it's been since 1988. (NASA)

It wasn't until 1985 that scientists were certain that this was a major problem and it was human-caused. The culprit were chemical compounds called chlorofluorocarbons (CFCs), which started to be used in the 1960s in air conditioners, aerosol spray cans, and industrial cleaning products. They were also used to make Styrofoam. And they were capable of breaking apart ozone molecules, causing the breakdown of ozone in the stratosphere to happen faster than it could be built back up.

Once in the atmosphere, CFCs drift slowly upward to the stratosphere, where they are broken up by ultraviolet radiation, releasing chlorine atoms, which are able to destroy ozone molecules.



This animation shows the destruction of an ozone molecule by a chlorine atom. UV radiation breaks a chlorine atom off a CFC molecule. The chlorine atom breaks an ozone molecule apart into an oxygen molecule (O_2) and a chlorine monoxide molecule (ClO). A free oxygen atom bumps the chlorine atom out, forming an oxygen molecule. This leaves the chlorine atom free to attack and destroy another ozone molecule. (UCAR/COMET)

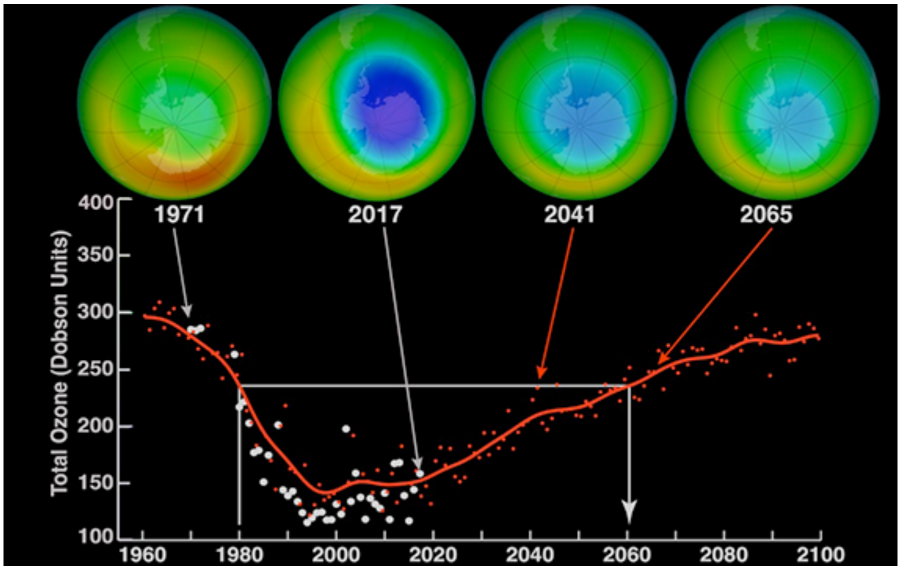
The seasons have an impact on the Antarctic ozone hole. During the dark winter, air swirls in a vortex with very low temperatures that cause icy clouds to form. Reactions on the surface of icy cloud particles release chlorine from chemical compounds like CFCs, into a form that reacts with ozone. When sunlight returns in the spring, the chlorine begins to destroy ozone.

There isn't much ozone depletion in the Arctic because icy clouds are less common and the vortex normally breaks down several weeks before sunlight returns in the spring.

Solving the Problem of Ozone Destruction

The Montreal Protocol, an international agreement to address the global problem of ozone destruction, was signed by more than 70 countries in 1986. It set goals of reducing CFC production 20% by 1993 and 50% by 1998. Since the agreement was signed, these targets have been strengthened to call for th elimination of the most dangerous CFCs by 1996 and for regulation of other ozone-depleting chemicals.

Scientists detected the problem and identified the cause of the problem. Their evidence convinced governments around the world to take action to help stop the problem. The global elimination of ozone-depleting chemicals from the atmosphere will take decades, but we have made progress on filling in th hole. It was the first time in history that we tackled a global-scale environmental issue with worldwide cooperation.



Images above the graph show a view of the South Pole in October over time including measurements taken in the past in 1971 and 2017 and model projections of ozone over the area for 2041 and 2065. The graph shows average minimum ozone over Antarctica in October.
Credit: NASA GSFC