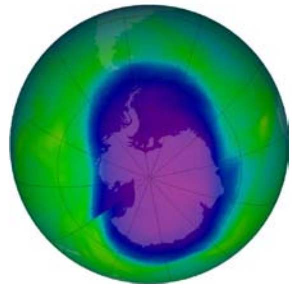
# The Antarctic 'Ozone Hole'



The Antarctic ozone hole is an area of the Antarctic stratosphere in which the recent (since about 1975) ozone levels have dropped to as low as 33% of their pre-1975 values. The ozone hole occurs during the Antarctic spring, from September to early December, as strong westerly wind start to circulate around the continent and create an atmospheric container. In this container over 50% of the lower stratospheric ozone is destroyed.

**Why is it important?**

While the effective of the Antarctic hole in decreasing the global ozone is relatively small, estimated at about 4% per decade, the hole has generated a great deal of interest because:
The decrease in the ozone layer was predicted in the early 1980's to be roughly 7% over a sixty-year period. The sudden and, at that time unexplained, disappearance of over 50% of the ozone layer in a localized area of Antarctica created quite a stir. Many were worried that ozone holes might start to appear over other areas of the globe but to date the only other significant, localized depletion is a much smaller ozone "dimple" (R.Parson FAQ) ; observed during the arctic spring over the north pole.
The Antarctic hole is a warning that if conditions become more Antarctic: cooler stratospheric temperatures, more stratospheric clouds, more active chlorine; then global ozone will decrease at a much greater pace. Some of the more popular scenarios of global warming predict that these changes could occur in larger portions of the stratosphere.
When the Antarctic ozone hole does break-up, the ozone-depleted air drifts out into nearby areas. Decreases in the ozone level of up to 10% have been reported in New Zealand in the month following the break-up of the Antarctic ozone hole [WMO 1991] [Atkinson et al.1989] [Roy et al. 1990]

**What is so special about Antarctic conditions?**

Polar regions get a much larger variation in sunlight than anywhere else, and during the 3 months of winter spend most of time in the dark without solar radiation. Temperatures hover around or below -80'C for much of the winter and the extremely low Antarctic temperatures cause cloud formation in the relatively "dry' stratosphere. These Polar Stratospheric Clouds (PSC's) are composed of ice crystals that provide the surface for a multitude of reactions, many of which speed the degradation of ozone molecules.

**Summary of what happens in the Antarctic hole**

1. As mid-May brings on the onset of winter, the Antarctic stratosphere cools and descends closer to the surface. The Coriolis effect (caused by the earths rotation) sets up a strong westerly circulation around the south pole, forming an oblong vortex which varies in size from year to year. Current theory [Tuck 1989] holds that the vortex is like a semi-sealed reaction vessel with most of the Antarctic air staying trapped inside the vortex. As temperatures in the lower stratosphere cools below -80'C, Polar Stratospheric Clouds (PSC's) start to form.

2. Most of the Antarctic stratospheric chlorine ends up in reservoir compounds such as $ClONO_2$ or HCl. Reservoir compounds are so named because they hold the atmospheric chlorine in an inactive form but can react later, usually after a hit by ultraviolet radiation, and release reactive chlorine molecules. On the surface of the PSC crystals, nitrogen compounds are readily absorbed and chlorine reservoir compounds are converted to far more reactive compounds such as $Cl_2$ and HOCl.

3. The small amounts of visible light during the Antarctic winter are sufficient to convert much of the atmospheric $Cl_2$ to ClO:

$$\mathbf{Cl_2 + light \text{ ---> } 2\,Cl}$$

$$\mathbf{Cl + O_3 \text{ ---> } ClO + O_2}$$

4. Ordinarily much of the ClO would be captured by atmospheric $NO_2$ and returned to the $ClONO_2$ reservoir, but the polar clouds have absorbed most of the Nitrogen compounds such as $NO_2$. 4. Spring brings an increase of ultraviolet light to the lower Antarctic stratosphere, providing the energy needed for the rapid catalytic break-down of ozone by ClO and its dimmer ClOOCl. Another mechanism involving Bromine adds another 33% to the depletion total. Over 50% of the stratospheric ozone is destroyed by these two mechanism, most of the damage occurring in the lower stratosphere.

5. Towards the end of spring (mid-December) the warming temperatures cause the vortex to break up; ozone-rich air from the surrounding area comes flooding in and masses of ozone-depleted air go wandering off, temporarily lowering the ozone in areas of South America and New Zealand by up to 10%.

**Factors influencing the magnitude of the hole** are essentially the same as those factors affecting global ozone levels[illegible]t an area of great uncertainty are the surface reactions that happen in the polar stratospheric clouds. Reactions have been proposed and tested in labs in which chlorine, bromine and nitrogen-oxides can cooperate to break down ozone many times faster than they could alone, and the presence of the polar clouds is important in this cooperation.

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