ALEXIS MERLAUD: SPRINGTIME OZONE HOLE OVER ANTARCTICA LASTING LONGER THIS YEAR

Alexis Merlaud is an atmospheric scientist from the Royal Belgian Institute for Space Aeronomy (BIRA-IASB). He is currently part of the 2020-2021 BELARE expedition, installing instruments dedicated to observing the atmosphere above Princess Elisabeth Antarctica. Dr. Merlaud dedicated some of his time to talk about the ozone hole over Antarctica that forms every year during the austral spring, and why this year's ozone hole is persisting longer than normal.

The hole in the ozone layer over Antarctica during the austral spring this year is lasting longer than normal. Why is this the case?

It has to do with the temperature in the stratosphere (the layer of Earth's atmosphere that sits at between about 10 and 50 km altitude, and which contains the protective ozone layer), and ozone-destroying chemicals such as chlorofluorocarbons (CFCs) that have remained in the atmosphere, even several decades after their use was banned.

CFCs are very stable gasses, which has allowed them to make their way from the ground into the stratosphere over time. Above the Antarctic, the cold stratospheric temperatures lead to the formation of polar stratospheric clouds (PSCs). The special chemistry at the surface of these clouds combined with the high-energy photons from the sun, break CFCs apart into their components. The chlorine atoms (Cl) that detach from CFCs when they break apart react chemically with ozone molecules (O_3), destroying them.

The ozone hole over Antarctica usually starts to appear in September as the sun returns to Antarctica, but it usually disappears by November, once the stratosphere has warmed up enough to stop the formation of PSCs. However this year, temperatures in the stratosphere have remained colder for longer than normal, thanks to a very stable polar vortex over Antarctica this spring.

What does the polar vortex over Antarctica have to do with the springtime ozone hole?

Polar vortexes exist over both the North Pole and the South Pole, due to Earth's rotation. While the Arctic Ocean and several surrounding landmasses make the polar vortex in the Northern Hemisphere less stable, the fact that you have the huge landmass of Antarctica surrounded by water makes the polar vortex in the Southern Hemisphere much more stable. This means that cold air masses over Antarctica don't mix with warmer air masses in the mid-latitudes as much as they do in the Northern Hemisphere.

If there's less mixing of polar air with warmer air from the mid-latitudes, then the part of the atmosphere inside the polar vortex remains thermally isolated, keeping it much colder for longer periods of time, and enabling the formation of PSCs and thus the destruction of ozone in sunlight.

The chemical state of the stratosphere has not changed much since last year when the ozone hole was - unlike this year - very short-lived. Meteorological conditions drive these short-term changes from year to year.

Explaining how the meteorological conditions in the stratosphere change each year is quite complicated. These changes are linked to the large natural oscillations of the Earth system, such as El Niño/Southern Oscillation, themselves changing partly due to man-made climate change.

Why are CFCs still destroying the ozone layer, decades after the 1987 Montreal Protocol banned their use?

The Montreal Protocol and subsequent treaties banning the use of ozone-depleting substances like CFCs have certainly had a noticeable effect. They've kept more ozone-depleting substances from entering the atmosphere and causing more damage.

However, their disappearance from the stratosphere is slow since these glasses are very stable. For instance, the lifetime of CFC-11 is 50 years. Its concentration in the atmosphere reached its peak in 1994 (270 ppt) but has since decreased to 220 ppt.

Unfortunately CFCs will remain in the stratosphere for several more decades. We estimate that a hole in the ozone will continue to form over Antarctica every austral spring until about 2060 if no more ozone-depleting substances are added to the atmosphere.

How long have scientists been observing the ozone layer?

Ozone is one of the easiest molecules in the atmosphere to observe, because of its strong absorption in the ultraviolet (UV) radiation from the sun

Scientists have been measuring ozone in the atmosphere since the beginning of the 20th century. The first European network of ground-based measurements of ozone began in the 1920s, and ground-based observations in Antarctica began in the 1950s, starting in earnest during the International Geophysical Year (IGY) in 1957-1958. Satellites have been observing atmospheric ozone levels since the 1960s.

Do we know whether an ozone hole ever occurred naturally prior to humans' use of CFCs?

As far as we know, there was no naturally-occurring ozone hole over Antarctica before humans started producing CFCs and other ozone-destroying chemicals.

There are natural sources of ozone-depleting substances. For instance, some volcanic eruptions and oceanic ecosystems produce them. However, the amount of such gasses they produce is too small to have any noticeable effect on the ozone layer.

For more information, I suggest consulting Twenty Questions and Answers about the Ozone layer, put together by the World Meteorological Organization (WMO).

What is your research team doing to keep track of the ozone hole over Antarctica?

The PEA Station has several scientific measurements to measure the ozone hole. During this season, we've installed two instruments to measure atmospheric ozone: a Brewer Spectrophotometer from the Royal Meteorological Institute of Belgium, and a MAX-DOAS instrument the Royal Belgian Institute for Space Aeronomy.

Note that this second instrument is first intended to measure the optical properties of aerosol but can also measure stratospheric ozone. This is important since we plan to install the MAX-DOAS permanently once the Brewer Spectrophotometer is removed at the end of the season. As long as the instrument is powered and running next September, we should be able to track the ozone hole's formation and growth during the austrla spring of 2021.

How does your work benefit the scientific community and those working in Antarctica?

The data we collect at the PEA Station contributes to the global scientific effort to monitor the ozone hole.

At the same time, our work also has immediate benefits for people working in Antarctica: it reminds them that they need to take extra care to cover their skin (by applying sunscreen) and protect their eyes when outdoors. It's possible to get a very bad sunburn or cause damage to your eyes in these high-UV conditions.