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Satellite instrument helps tackle mysteries of ozone-eating clouds

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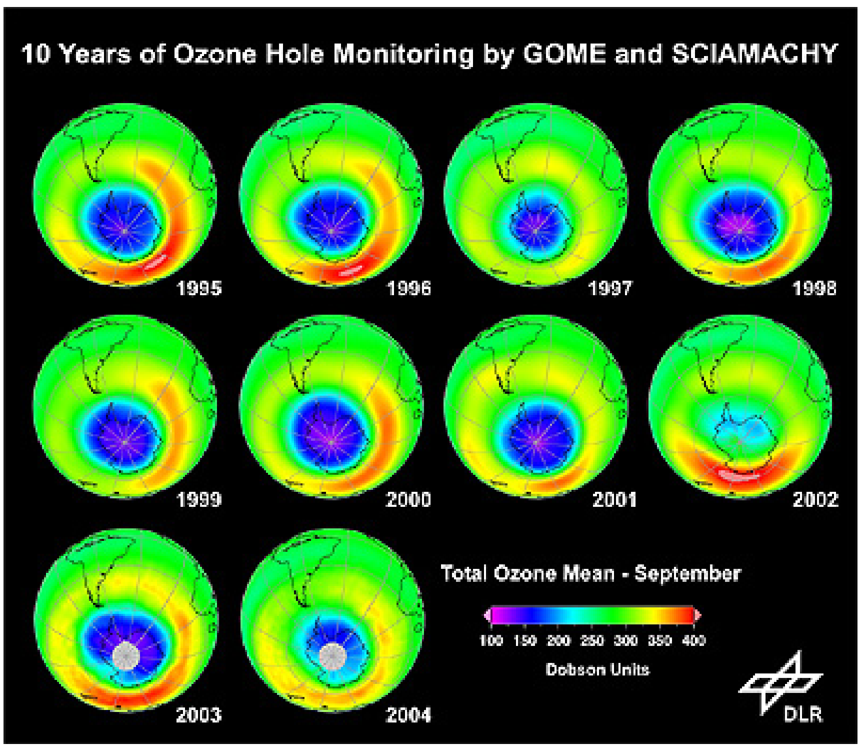
Polar stratospheric clouds are often referred to as mother-of-pearl clouds because of their iridescent appearance. These clouds form in altitudes between 20 and 30 kilometres when temperatures drop to minus 80 degrees Celsius and play a vital role in ozone destruction. Credits: David Hay Jones/tunc.biz

Polar stratospheric clouds have become the focus of many research projects in recent years due to the discovery of their role in ozone depletion, but essential aspects of these clouds remain a mystery. MIPAS, an instrument onboard ESA's Envisat, is allowing scientists to gain information about these clouds necessary for modelling ozone loss.

"The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is unique in its possibilities to detect polar stratospheric clouds (PSCs) since it is the first instrument with the ability to observe these clouds continuously over the polar regions especially during the polar night," Michael Höpfner of Germany's Forschungszentrum Karlsruhe GmbH said.

Using data collected by MIPAS, a German-designed instrument that observes the atmosphere in middle infrared range, Höpfner and other scientists discovered a belt of nitric acid trihydrate (NAT) PSCs developing in the polar night over Antarctica in 2003 about one month after the first PSCs, which were composed of water crystals, were detected.



10 years of ozone hole monitoring. Credits: DLR

There are two classifications of PSCs – Type I clouds contain hydrated droplets of nitric acid and sulphuric acid, while Type II clouds consist of relatively pure water ice crystals.

The presence of NAT was detected because of MIPAS' ability to map the atmospheric concentrations of more than 20 trace gases, including ozone as well as the pollutants that attack it.

"This has been the first evidence for the existence of NAT PSCs on a large scale," Höpfner said. NAT particles, which contain three molecules of water and one molecule of nitric acid, enhance the potential for ozone destruction in polar regions.

The thinning of the ozone is caused by the presence of man-made pollutants in the atmosphere such as chlorine, originating from man-made pollutants like chlorofluorocarbons (CFCs). During the southern hemisphere winter, temperatures drop to very low levels causing the chemicals in the stratosphere, which is in complete darkness during the winter, to freeze and form PSCs that contain chlorine.

Now banned under the Montreal Protocol, CFCs were once widely used in aerosol cans and refrigerators – and have not vanished from the air. CFCs themselves are inert, but ultraviolet radiation high in the atmosphere breaks them down into their constituent parts, which can be highly reactive with ozone.

As the polar spring arrives, sunlight returns and creates chemical reactions in PSCs responsible for converting benign forms of chlorine into highly ozone-reactive radicals that spur ozone depletion. A single molecule of chlorine has the potential to break down thousands of molecules of ozone.

NAT PSCs enhance the potential for chlorine activation and can also sediment and irreversibly remove nitrogen from the lower stratosphere, causing a process known as denitrification, which slows the return of chlorine to its inactive form and allows for ozone destruction to continue.

Höpfner and fellow scientists were able to explain the sudden NAT formation of PSCs in 2003 by temperature disturbances in waves over the Antarctic Peninsula and the Ellsworth Mountains, suggesting a more significant role for mountain waves in the formation of Antarctic's PSCs than previously thought.

According to Höpfner, the presence of PSCs could intensify in the future due to a globally changing climate where the Earth's surface gets warmer due to trapped greenhouse gases but the stratosphere gets colder, providing an environment in which the clouds can form. An increase in PSCs could counteract the recovery of the ozone layer.

Although scientific efforts have focused on determining PSC composition and their formation mechanisms, the process causing the ozone depletion is far from understood. In order to gain a better understanding of ozone depletion, scientists must continue obtaining data which allows them to measure the key species involved in the process.

Source: European Space Agency

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