Huge 2004 stratospheric ozone loss tied to solar storms, Arctic winds

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A new study led by the University of Colorado at Boulder indicates that two natural atmospheric processes in 2004 caused the largest decline in upper stratospheric ozone ever recorded over the far Northern Hemisphere.

According to Research Associate Cora Randall of CU-Boulder's Laboratory for Atmospheric and Space Physics, nitrogen oxide and nitrogen dioxide gases in the upper stratosphere climbed to the highest levels in at least two decades in spring 2004. The increases led to ozone reductions of up to 60 percent roughly 25 miles in altitude above Earth's high northern latitudes, said Randall.

"This decline was completely unexpected," she said. "The findings point out a critical need to better understand the processes occurring in the ozone layer." Randall is chief author of a paper on the subject appearing in the March 2 online issue of Geophysical Research Letters, published by the American Geophysical Union.

Randall worked with an international team of scientists from the United States, Canada and Europe to look at data from seven different satellites, concluding both the sun and stratospheric weather were responsible for the ozone declines.

Winds in the upper part of a massive winter low-pressure system that confines air over the Arctic region, known as the polar stratospheric vortex, sped up in February and March 2004 to become the strongest on

record, she said. The spinning vortex allowed the nitrogen gases, believed by the team to have formed at least 20 miles above the stratosphere as a result of chemical reactions triggered by energetic particles from the sun, to descend more easily into the stratosphere.

The increases in the two nitrogen gases -- collectively known as NOx -- are important because they are major players in the stratospheric ozone destruction process, said Randall. The team concluded that some of the extra NOx seen in the springtime was actually formed after huge quantities of energetic particles from the sun bombarded Earth's atmosphere during the Halloween solar storms of 2003.

"No one predicted the dramatic loss of ozone in the upper stratosphere of the northern hemisphere in the spring of 2004," she said. "That we can still be surprised illustrates the difficulties in separating atmospheric effects due to natural and human-induced causes.

"This study demonstrates that scientists searching for signs of ozone recovery need to factor in the atmospheric effects of energetic particles, something they do not now do."

The 2004 enhancements of NOx gases in the upper stratosphere and subsequent ozone losses occurred over the Arctic and the northern areas of North America, Europe and Asia, said the paper authors. Severe ozone losses also can occur during winter and spring in the stratosphere at about 12 miles in altitude, driven primarily by very cold temperatures, they said.

Because of seasonal conditions, the researchers are unable to measure the precise contributions of solar storms and stratospheric weather to the NOx spike seen in the stratosphere last year. "No observations of upper atmospheric nitrogen gases are available in the polar region in the winter, so the descending NOx cannot be traced to its origin," said Randall.

A form of oxygen, ozone protects life on Earth from the harmful effects of ultraviolet radiation. The ozone layer has thinned markedly in high latitudes of the Northern and Southern Hemispheres in recent decades, primarily due to reactions involving chlorofluorocarbons and other industrial gases.

Scientists believe the 1987 Montreal Protocol, an international agreement that has phased out the production and use of such ozone-destroying compounds, may allow the protective ozone layer to be restored by the middle of this century.

Source: University of Colorado at Boulder