Evidence shows increased risk of ozone loss over the US in summer

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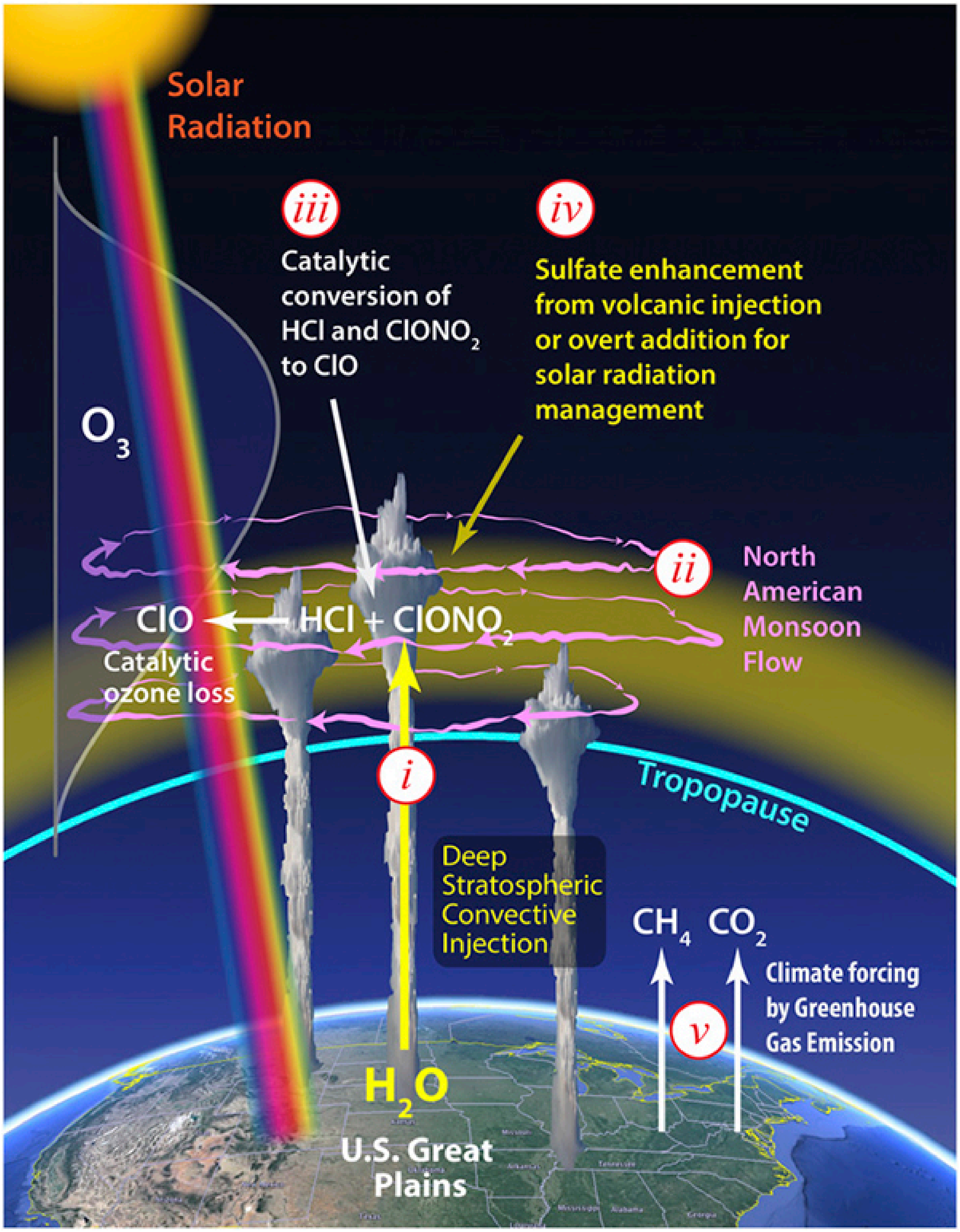

Credit: Harvard University

A new study out of Harvard University reveals that the protective stratospheric ozone layer above the central United States is vulnerable to erosion during the summer months from ozone-depleting chemical reactions, exposing people, livestock and crops to the harmful effects of UV radiation.

Powerful storm systems common to the Great Plains inject water vapor that, with observed temperature variations, can trigger the same chemical reactions over the central United States that are the cause of ozone loss over the polar regions, according to a new paper published in the *Proceedings of the National Academy of Sciences*.

The paper, led by James G. Anderson, the Philip S. Weld Professor of Atmospheric Chemistry at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS), found that stratospheric ozone concentrations over the United States in summer are vulnerable to both increases in water vapor and observed variations in temperature from storm systems over the Great Plains. Increased frequency and intensity of these storm systems, as well as longer-term decreases in stratospheric temperatures, are expected to accompany climate change.

Using extensive aircraft observations in the Arctic stratosphere from the early 2000's, researchers established the chemical framework defining enhanced ozone loss rates with respect to temperature and water vapor. Then they employed recent NEXRAD weather radar observations to demonstrate that on average 4000 storms each summer penetrate into the stratosphere over the central United States, which is far more frequent than was previously thought.

This combination of circumstances puts the stratosphere over states including Texas, Oklahoma, Kansas, Nebraska, Iowa, Missouri, the

Dakotas and states that border the Great Plains, at risk for chemical reactions that deplete ozone during summer, potentially leading to higher levels of exposure to damaging UV light from the sun.

"These developments were not predicted previously and they represent an important change in the assessment of the risk of increasing UV radiation over the central US in summer," said Mario J. Molina of the University of California San Diego, the 1995 Nobel Prize winner in stratospheric chemistry, who was not involved in this research.

Stratospheric ozone is one of the most delicate aspects of habitability on the planet. There is only marginally enough ozone in the stratosphere to provide protection from UV radiation for humans, animals and crops. Medical research specific to the United States has determined that a 1 percent decrease in the amount of ozone in the stratosphere corresponds to a 3 percent increase in the incidence of human skin cancer. There are now 3.5 million new cases of skin cancer each year reported in the US alone. Thus, for each 1 percent reduction in ozone, there would be an additional 100,000 new cases of skin cancer annually in the United States.

"Thunderstorms that hydrate the stratosphere can have significant local and regional impacts on Earth's radiation budget and climate," said Cameron R. Homeyer of the University of Oklahoma, a co-investigator on the paper. "This work demonstrates our increasing knowledge of such storms using ground-based and airborne observations and evaluates their potential for depleting stratospheric ozone now and in the future. The results strongly motivate the need for increased meteorological and chemical observations of such storms."

"Every year, sharp losses of stratospheric ozone are recorded in polar regions, traceable to chlorine and bromine added to the atmosphere by industrial chlorofluorocarbons and halons," said Steven C. Wofsy, the

Abbott Lawrence Rotch Professor of Atmospheric and Environmental Science at SEAS and co-author of the study. "The new paper shows that the same kind of chemistry could occur over the central United States, triggered by storm systems that introduce water, or the next volcanic eruption, or by increasing levels of atmospheric carbon dioxide. We don't yet know just how close we are to reaching that threshold."

The scientific community has observed the chemical reactions that attack ozone over the polar regions in winter, but the important combination of observations that define the cause and the rate of stratospheric ozone loss have never been made over the central US in summer. This represents a major shortcoming in researchers' ability to forecast increases in UV radiation that might result from a volcanic event or climate change now and in the years to come.

"Rather than large continental-scale ozone loss that occurs over the polar regions in winter characterized, for example, by the term Antarctic ozone hole, circumstances over the central US in summer are very different," said Anderson. "In particular, because of the very frequent storm-induced injection events detailed by studies at Texas A&M and the University of Oklahoma using advanced radar methods, this structure of highly localized but numerous regions of potential ozone loss requires carefully specified observational strategies and systematic surveillance in order to provide the basis for accurate weekly forecasts of ozone loss."

The researchers are calling for extensive characterization of the stratosphere over the central United States in order to forecast short-term and long-term ozone loss related to increasing frequency and intensity of storm systems, higher levels of atmospheric carbon dioxide and methane, and other factors.

More information: James G. Anderson el al., "Stratospheric ozone over the United States in summer linked to observations of convection and temperature via chlorine and bromine catalysis," *PNAS* (2017). www.pnas.org/cgi/doi/10.1073/pnas.1619318114

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