A Review Paper on Causes of Antarctica Ozone Hole

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Abstract— Ozone also known as trioxygen, is an inorganic molecule having chemical formula O3. Ozone is naturally formed in atmosphere by a process called photolysis in which an O2 molecule splits and joins with another O2 molecule to form O3. It is present in its highest concentration high in the ozone layer of the stratosphere, which absorbs most of the Sun's ultraviolet (UV) radiation whose direct incoming could be dangerous for various forms of life. The discovery of the annual depletion of ozone above the Antarctic was first announced during a paper by Joe Farman, Brian Gardiner and Jonathan Shanklin which appeared in Nature in May 1985. The following review paper focuses on the facts why ozone holes occur dominantly over Antarctica.
Keywords: Antarctica Ozone Hole

I. Introduction

Antarctica is Earth's southernmost continent. It is situated in the geographic South Pole's Antarctic region of the Southern Hemisphere. The entire south of the Antarctic Circle is surrounded by the Southern Ocean. Antarctica, on the basis of weather and climate, is the coldest, driest, and windiest continent all the continents [1]. Most of Antarctica may be a polar desert, with annual precipitation of 200 mm (7.9 in) along the coast and much less inland; there has been no rain there for almost 2 million years, yet 80% of the world freshwater reserves are stored there, enough to raise global sea levels by about 60m (100ft) if all of it were to melt [2].

Ozone depletion is observed and read in two events since the late 1970s: the first observation made was a steady lowering of about four percent in the total amount of ozone, and a way larger springtime decrease in stratospheric ozone around Earth's Polar Regions. The second relative event is ozone hole. The major causes of ozone depletion and the ozone hole are manufactured chemicals; halocarbon solvents, refrigerants, propellants etc also referred to as ozone-depleting substances (ODS). These compounds reach into the stratosphere by stormy and rigorous mixing after being emitted from the surface, into the atmosphere. Once in the stratosphere, they release halogen atoms through photodissociation, which catalyze the breakdown of ozone (O3) into oxygen (O2). Both types of ozone depletion were observed to increase as emissions of halocarbons increased [3].

The measurement of hole is completed by reduction within the total column ozone above some extent on the surface expressed in Dobson units; abbreviated as "DU". The most prominent decrease in ozone has been within the lower stratosphere. Marked decreases in column ozone within the Antarctic spring and early summer compared to the first 1970s and before are observed using instruments like the entire Ozone Mapping Spectrometer (TOMS) [4].

II. Discussion [5]

The ODS are present throughout the stratospheric ozone layer because as they are transported to great distances by atmospheric air motions. The acute depletion of the ozone layer known as the “ozone hole” occurs dominantly over Antarctic because of the special atmospheric and chemical conditions that exist in its atmosphere and nowhere else on the earth. The very low winter temperatures cause polar stratospheric clouds (PSCs) to form. Reactions that occur on PSCs, in combination of isolation of polar stratospheric air, allow chemicals like chlorine and bromine reactions to damage the ozone in Antarctic springtime. The other conditions which are reported to add to the depletion of ozone over Antarctic are discussed briefly as under;

1) Distributing halogen gases. Halogen source gases emitted at Earth’s surface are present in comparable abundances in the stratosphere in both hemispheres. Halogen gases enter the stratosphere primarily from the tropical upper troposphere. Stratospheric air motions then transport these gases upward and toward the pole in both hemispheres.
2) Low polar temperatures. Antarctic has very low temperatures which are important because they allow liquid and solid PSCs to form. The winter temperatures are as to form PSCs in the Antarctic for nearly the entire winter.
3) Isolated conditions. Stratospheric air in the Polar Regions remains isolated from other stratospheric regions for winter months. The isolation occurs because of strong winds that surround the poles, giving rise to a polar vortex, which prevents mingling or movement of air into or out of the polar stratosphere. Once chemical reactions occur in these regions and form PSCs, the isolation contains those changes for week and months.
4) Polar stratospheric clouds (PSCs). Reactions on the surfaces of liquid and solid PSCs can result in the formation of many chlorine gases. These reactions convert the abundant reactive chlorine gases, chlorine nitrate (ClONO2) and acid (HCl), to the foremost reactive form, ClO. ClO increases from a small fraction and changes all the chlorine available.
5) Nitric acid and water removal. Once formed, PSC particles fall to lower altitudes due to gravity. The largest particles can descend several kilometres or more within the stratosphere during the low-temperature winter/spring period that lasts several months in Antarctica. Because PSCs often contain a big fraction of obtainable HNO3, their descent removes HNO3 from regions of the ozonosphere. This process is called denitrification of the stratosphere. With less HNO3, the highly reactive chlorine gas ClO remains chemically active for an extended period, thereby increasing chemical ozone destruction.

The measurement of ozone started as early as 1950s and has evolved over time. The current measurement of ozone is performed by various satellites namely [6],

- The Total Ozone Mapping Spectrometers (TOMS)
- Data from the Ozone Monitoring Instrument (OMI)
- Earth Observing Satellite (EOS)
- OMPS (Ozone Mapping and Profiler Suite)

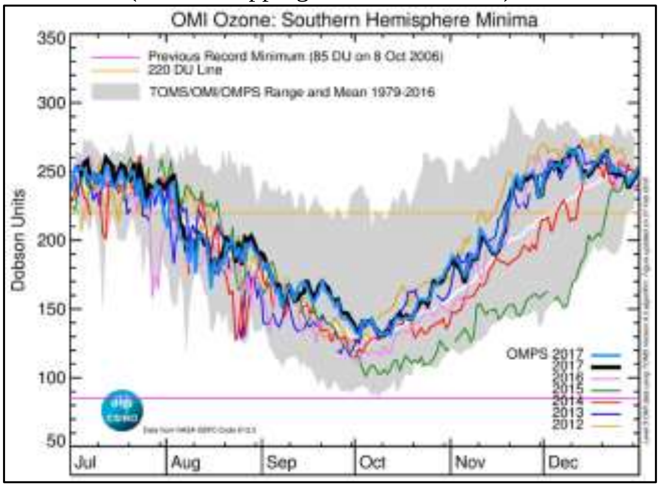

Fig. 1: Ozone hole 'depth' (minimum ozone, DU) based on OMI & OMPS satellite data. [7]

III. Conclusion

The 2017 Antarctic hole was one among the littlest since the 1980s in comparison to all or any of the previous ozone holes. The 2017 hole ranked between 26th-29th over a number of metrics for the 38 holes assessed since 1979. The size and depth of the 2017 hole was impacted by a series of huge dynamical disturbances of the polar vortex that caused significant warming events, which limited ozone loss. The 2000 and 2006 ozone holes were the largest ozone holes ever, depending on the metric that is used [8]. To heal the ozone layer, we must stop releasing ozone-depleting compounds into the atmosphere. Scientists hope that the ozone layer will return to normal within fifty years of completely stopping the release of compounds viz., CFCs (chlorofluorocarbons), halogenated hydrocarbon, methyl bromide and nitrous oxide.

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