O_3

OZONE

V1.0

WHAT IS THIS GAS?

Origins

Ozone is created when VOC (volatile organic compounds) and NO_x (oxides of nitrogen) combine in sunlight, making it a secondary pollutant. The combining processes control the amount of ground level ozone, and they are primarily anthropogenic. There are natural production methods of VOC and NO_x, for example, soils, vegetation, and natural fires. The predominant anthropogenic contributors to VOC and NO_x are combustion, transportation, power stations, oil productions, and solvents. Creating VOC and NO_x intensifies the likelihood of ozone formation.

What is the current PPM of this gas? And the atmospheric trend since 1700 and since 1960?

In 2020, ozone concentration was approximately 0.042 PPM. It is important to note that this measurement was recorded during the COVID-19 lockdown, when people were not traveling nearly as much as usual. Perhaps a more honest measurement of O_3 would be 2019's measurement: 0.045 PPM. In 1986, ozone concentrations measured to be approximately 0.032 PPM. Preindustrial ozone (before 1750) measured approximately 0.024 PPM. Weather and climate play a large role in the formation of tropospheric ozone. It prefers to form on warm, sunny days when the air is stagnant. Geographic location is another influential factor in ozone formation. These factors can cause variations in PPM measurements daily as well as hourly.

Why is this gas important to climate change? How long does it remain in the atmosphere?

Ozone is an essential factor to allow life on Earth to flourish. Ozone in the stratosphere provides benefits while ozone in the troposphere can be harmful. Tropospheric ozone causes smog which can contribute to lung-related illnesses (asthma, COPD). The natural ozone layer in the stratosphere prevents harmful UV radiation (via the sun) from reaching the ground. Tropospheric ozone is increasing while stratospheric ozone is decreasing. Other greenhouse gases such as CFCs (chlorofluorocarbons) and HCFCs (Hydrochlorofluorocarbons) contribute to the diminishing stratospheric ozone layer due to the toxins they emit. Tropospheric ozone is created through the reaction of VOC and NO_x in sunlight. This reaction / combination can create smog; known for its lung related complications. Short term smog exposure can be felt right away. Symptoms might include shortness of breath, wheezing, and coughing. Long term exposure can result in the development of respiratory disease. Premature death is a potential consequence of long-term exposure. Ozone only stays in the atmosphere for 30 min – 4 hrs, meaning it has a shorter life span compared to some other greenhouse gases. While it does not have a very lengthy life, ozone is still impacting human health as well as climate change. Over a span of 100 years, ozone's GWP lies within the range of 918-1022. Over 20 years, however, its GWP is 62-69.

What is an appropriate PPM goal to meet 1.5 degree threshold?

In the United States, ozone is regulated. There is an 8-hour regulated standard of 0.08 PPM. This is calculated by measuring the number of days per year in a certain area (such as a metro area or county) that exceeds an 8-hour ozone concentration of 0.08 PPM. In 1987, the Montreal Protocol was agreed upon to reduce the production as well as consumption of products and practices which deplete stratospheric ozone. The Montreal Protocol was a global agreement, it is considered one of (if not the) best, most successful environmental feats ever. HCFCs and CFCs are produced by refrigerants and aerosols as well as air conditioning units. These compounds are depleting the stratospheric (essential) ozone layer.

REDUCTION POTENTIAL

Can emissions be reduced?

"Emissions" (or production) can be reduced. There is opportunity on a personal / individual level as well as a larger scale, industrial level for ozone production to be reduced. Transportation is a large contributor to tropospheric ozone, taking public transportation or reducing the amount of fuel usage is a step to reducing ozone. Cities have displayed ozone alert signs, instructing people to please refuel vehicles after dark, mow the lawn after dark, and to stay inside as much as possible. Refueling vehicles and mowing lawns after dark reduces VOC emissions. VOCs (and NO_x) enjoy sunlight, so refueling and utilizing fueled vehicles after dark reduces the production of VOCs. Staying inside as much as possible is more of a health concern, as exposure to ozone can be dangerous. The Montreal Protocol has made a significant impact on the preservation of the stratospheric ozone. Placing limitations or bans on CFCs and HCFCs has controlled the amount of stratospheric ozone depletion.

Can emissions be captured at source?

Ozone itself cannot be captured at the source because it is a result of a chemical reaction between VOCs and NO_x. Collecting both contributors to ozone formation is a more likely option by capturing them at places such as chemical manufacturing plants, where they are likely to be found.

Can this gas be removed from the atmosphere or ocean?

Ozone is found in the troposphere as ground-level ozone. It is also found in the stratosphere as one of the natural elements of Earth's atmosphere. Ozone is not as common in the ocean, there is a thin layer of tropospheric ozone just above the water, some of which gets absorbed. Ground level, tropospheric ozone is the main concern and main target for removal. It can be removed from the atmosphere, but it is done on a very small scale.

TECHNOLOGY REMAINS IN DEVELOPMENTAL STAGES

What are current and potential <u>removal</u> technologies?	Ozone removal is typically conducted on a small scale, for example, ozone removal from a large, industrial room. It is important to note that there is not scaled, developed technology for the greater environment (such as the scalability of DAC for carbon dioxide). On a small scale, ozone can be removed via the utilization of the following: carbon filters, catalytic decomposition, and photocatalytic decomposition. Catalytic decomposition is an efficient (and relatively common) practice to remove ozone. Removal is completed by decomposing ozone to oxygen when it is at room temperature.
Which of these technologies are potentially scalable?	Catalytic decomposition (carbon filters and photocatalytic decomposition) is practiced on a very small scale compared to other removal strategies such as direct air capture. Catalytic decomposition is used on an industrial scale, in a factory room, per say. These technologies are not largely utilized.

FOR EACH TECHNOLOGY:

What are the uses of the removed gas?	Because catalytic decomposition decomposes ozone into oxygen, it is released back out as oxygen.
If the use is sequestration, what is the sequestration time frame?	Ozone removal is typically done on a relatively small scale. There is not technology being currently utilized that is scaled to capture large volumes of ozone, instead reduction methods are highlighted as opposed to removal. Given that there is not large-scale technology for removal, ozone is not sequestered.
What is the net energy requirement to process removal?	There is not large-scale technology to remove ozone from the atmosphere as there is with carbon dioxide (DAC). Because that technology is yet to exist on a such a scale, there is no removal, therefore, no calculated net energy.