



# A Review Paper on Ozone layers depletion and uv radiation

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**Abstract-** The preservation of the stratospheric ozone layer is vital for shielding terrestrial life from mutagenic ultraviolet (UV) radiation. While the Montreal Protocol effectively addressed chlorofluorocarbons (CFCs), the rapid expansion of the global aviation sector has introduced a significant, direct source of ozone-depleting pollutants into the sensitive upper troposphere and lower stratosphere (UTLS). This paper examines the chemical and physical mechanisms by which aircraft exhaust—comprising Nitrogen Oxides (NO<sub>x</sub>), water vapor, and sulfate aerosols—catalyzes the breakdown of O<sub>3</sub> molecules. Unlike ground-level emissions, aircraft operate at altitudes where their effluents have a prolonged residence time, allowing NO<sub>x</sub> to engage in continuous catalytic cycles that destroy ozone more efficiently than at lower altitudes.

**Keywords:** Base Isolation, Fixed Base RC Structure, Seismic Analysis, SAP2000v16 software, HDRB base isolators.

## I.INTRODUCTION

Earth's primary biological shield, absorbing the vast majority of the sun's high-frequency ultraviolet (UV) radiation. While the landmark Montreal Protocol successfully initiated the phase-out of terrestrial ozone-depleting substances like chlorofluorocarbons (CFCs), the rapid expansion of the global aviation sector introduces a unique and growing threat to this atmospheric recovery. The stratospheric ozone layer serves as the sector introduces a unique and growing threat to this atmospheric recovery. As the only human activity that injects pollutants directly into the Upper Troposphere and Lower Stratosphere (UTLS), aviation bypasses the natural "filtering" processes of the lower atmosphere. This direct deposition of chemical effluents creates a distinct set of perturbations that threaten the long-term stability of the ozone layer.

The core of the environmental challenge lies in the chemistry of high-altitude combustion. Aircraft engines emit a potent cocktail of Nitrogen Oxides (NO<sub>x</sub>), water vapor, and sulfate aerosols. At standard cruising altitudes (10–12 km) and the higher altitudes targeted by the next generation of Supersonic Transport (SST) (15–20 km), these substances act as aggressive catalysts. A single molecule of nitric oxide can facilitate a chain reaction that destroys thousands of ozone molecules before it is eventually neutralized. Furthermore, the introduction of water vapor into the dry stratosphere promotes the formation of polar stratospheric clouds, which provide the physical surfaces necessary for rapid, large-scale chemical ozone decay.

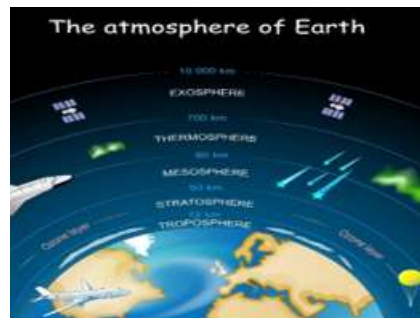
This paper is motivated by a critical paradox in modern aerospace engineering: the push for "green" aviation. Many technological advancements designed to reduce carbon dioxide (CO<sub>2</sub>) emissions—such as higher-pressure engine cycles—can inadvertently lead to higher combustion temperatures and increased NO<sub>x</sub> production. As we stand on the precipice of a resurgence in high-speed travel and increased global flight frequency, it is imperative to move beyond a carbon-only view of environmental impact. This introduction frames aviation not merely as a contributor to global warming, but as a direct chemical agent of stratospheric change. By examining the intersection of aerosol physics and atmospheric chemistry, this study aims to define the "ozone-safe" boundaries within which the future of flight must operate to preserve our planet's primary defense system.

The depletion of the ozone layer is one of the most significant environmental challenges of the modern era. While it sounds like a complex chemistry problem, it essentially boils down to a protective "sunscreen" in our atmosphere getting thinner due to human-made chemicals.

### 1. What is the Ozone Layer?

The ozone layer is a thin region of the Earth's stratosphere (located about 15 to 35 km above Earth) that contains high concentrations of ozone (O<sub>3</sub>) molecules.

- **The Shield:** It absorbs 97% to 99% of the sun's medium-frequency ultraviolet (UV) light.
- **Vital Function:** Without this layer, the intense UV radiation would sterilize the Earth's surface, making life as we know it impossible.



### 2. Causes of Depletion

The primary cause is the release of Ozone-Depleting Substances (ODS). When these reach the stratosphere, they are broken down by UV light, releasing chlorine and bromine atoms that destroy ozone molecules.

- **Chlorofluorocarbons (CFCs):** Previously used in air conditioners, refrigerators, and aerosol sprays.
- **Halons:** Used in fire extinguishers.
- **Carbon Tetrachloride:** Used in solvents and industrial processes.
- **Methyl Chloroform:** Used in various industrial cleaning agents.

### 3. The "Ozone Hole" Phenomenon

While ozone thins globally, the most severe depletion occurs over Antarctica during the spring.

- **Polar Stratospheric Clouds (PSCs):** In extreme cold, these clouds form and provide a surface for chemical reactions that drastically speed up ozone destruction.
- **The Result:** A massive "hole" where ozone levels drop by as much as 60% compared to historical levels.

### 4. Impact of Depletion

If the ozone layer continues to thin, the increased UV-B radiation reaching Earth leads to:

Category	Impact
Human Health	Increased rates of skin cancer, cataracts, and weakened immune systems.



Category	Impact
Marine Life	Damage to phytoplankton, which forms the base of the ocean food chain.
Terrestrial Plants	Stunted growth and reduced crop yields for species like rice, wheat, and corn.
Materials	Faster degradation of plastics, wood, and fabrics used outdoors.

### 5. Important Facts & Solutions

- **The Montreal Protocol (1987):** A landmark international treaty designed to phase out the production of ODS. It is considered the most successful environmental agreement in history.
- **Recovery:** Scientists have observed signs of healing. If current policies remain in place, the ozone layer is expected to recover to 1980 levels by approximately 2040 (and by 2066 over Antarctica).
- **The Climate Link:** Many ozone-depleting substances are also potent greenhouse gases. By phasing them out, we have also significantly slowed global warming.

### 6. The Chemical Chain Reaction

- The reason ozone depletion is so dangerous is the catalytic nature of the destruction. It isn't a one-to-one reaction; it is a cycle that repeats thousands of times.
- UV Breakdown: UV radiation hits a CFC molecule (CFC13) and breaks off a chlorine atom (Cl).
- The Destruction Cycle: The free chlorine atom attacks an ozone molecule (O<sub>3</sub>), pulling an oxygen atom away to form Chlorine Monoxide (ClO) and leaving behind an ordinary oxygen molecule (O<sub>2</sub>).
- The Regeneration: A free oxygen atom then attacks the ClO, releasing the chlorine atom back into the atmosphere to destroy another ozone molecule.
- The Statistic: A single chlorine atom can remain in the stratosphere for decades, destroying upwards of 100,000 ozone molecules before it is finally neutralized.

### 7. Why Antarctica? (The Polar Vortex)

- You might wonder why the "hole" is over the South Pole when most CFCs were released in the Northern Hemisphere.
- Atmospheric Circulation: Global winds transport ODS to the poles.
- The Polar Vortex: During the dark winter months, a constant whirl of cold air (the vortex) traps these chemicals over the Antarctic.
- The Spring Trigger: When sunlight returns in September (Antarctic Spring), the UV light reacts with the trapped chemicals all at once, creating a "chemical burst" that thins the ozone rapidly.

### 8. The "HFC" Dilemma (The Green Paradox)

- When the world moved away from CFCs, industries switched to Hydrofluorocarbons (HFCs).
- The Good News: HFCs do not contain chlorine and therefore do not deplete the ozone layer.
- The Bad News: HFCs are extremely potent greenhouse gases, some being thousands of times more effective at trapping heat than CO<sub>2</sub>.
- The Fix: In 2016, the Kigali Amendment was added to the Montreal Protocol to phase out HFCs as well, making the ozone treaty a major tool for fighting climate change.

### 9. Modern Threats to Recovery

- While we are on the path to recovery, new risks have emerged in the 2020s:
- Mega-Wildfires: Massive fires (like those in Australia in 2020) send smoke plumes into the stratosphere, which can trigger chemical reactions that temporarily deplete ozone.
- Rocket Launches: As the space industry grows, rocket emissions deposited directly into the upper atmosphere are becoming a concern for ozone health.



- **Illegal Emissions:** In recent years, scientists detected unexpected spikes in CFC-11 coming from specific regions in East Asia, despite the global ban. This highlighted the need for constant satellite monitoring.

### 10. Summary Table of Ozone Types

It is important to distinguish between "Good" and "Bad" ozone:

Feature	Stratospheric Ozone (The Shield)	Ground-Level Ozone (Smog)
Location	10–50 km above Earth	Surface level (Troposphere)
Role	Protects us from UV radiation	Harmful pollutant; causes respiratory issues
Formation	Naturally by UV light	Human-made (car exhaust + sunlight)
Status	Recovering due to policy	Increasing in many urban areas

## II. CHALLENGES AND FURTHER DIRECTIONS

The recovery of the ozone layer has entered a complex "final mile." While the 1987 Montreal Protocol was a success, several modern hurdles remain to ensure full restoration by 2066.

### 1. The "Feedstock" Loophole

While commercial use is banned, chemicals are still produced as "feedstocks" to create other products. Recent data indicates that leakage from these industrial processes is significantly higher than previously estimated.

### 2. Managing ODS "Banks"

Old refrigerators, air conditioners, and insulation foams currently in landfills contain massive amounts of trapped CFCs. As this equipment degrades, it leaks "zombie emissions" into the atmosphere.

### 3. Wildfire & Climate Feedback

Intense "Mega-fires" (like those in Australia and the Amazon) send smoke particles into the stratosphere. These particles trigger chemical reactions that temporarily destroy ozone, potentially delaying recovery.

### 4. The Impact of the Space Race

The surge in commercial rocket launches injects soot and aluminum oxide directly into the upper atmosphere. These emissions disrupt the stratosphere's delicate chemical balance in ways not yet fully regulated.

### 5. Illegal Trade & "Ghost" Emissions

Unexplained spikes in banned chemicals (like CFC-11) suggest that illegal production continues in regions with weak enforcement. This requires a shift toward AI-powered satellite surveillance to pinpoint sources.

### 6. The Kigali Amendment & HFCs

The world is now transitioning away from HFCs—chemicals that saved the ozone but are potent greenhouse gases. The future direction involves moving toward "Natural Refrigerants" like ammonia and .

### 7. Strategic Monitoring of the Polar Vortex

Climate change is making the Polar Vortex more unstable. Even as chemical levels drop, an unpredictable vortex can lead to sudden, severe ozone thinning over the poles, requiring more advanced atmospheric modeling.

## III. CONCLUSION

The story of the ozone layer is a powerful testament to both human impact and environmental resilience. While the discovery of the "ozone hole" in the 1980s served as a global wake-up call regarding the dangers of industrial chemicals, the subsequent success of the Montreal Protocol proved that international cooperation can effectively reverse planetary damage.



However, the journey to full recovery is not yet over. As we move toward the mid-21st century, the focus has shifted from simple chemical bans to addressing complex modern challenges such as illegal emissions, the impact of mega-wildfires, and the growing frequency of rocket launches. Furthermore, the transition away from HFCs through the Kigali Amendment highlights the critical link between ozone protection and the broader fight against climate change.

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