

****THE FUTURE OF THE ATMOSPHERE'S CLEANSING SYSTEM:**

A PUBLIC SUMMARY OF NEW SCIENCE AND EMERGING SOLUTIONS**

*A four-page overview for the public, based on Liu et al. (2024) and ReductionTech's OH\ oxidant-restoration concept**

Why the Hydroxyl Radical (OH) Matters

The hydroxyl radical (OH) is the atmosphere's primary cleansing agent. It removes methane, carbon monoxide, volatile organic compounds, and many short-lived climate pollutants. Scientists often call OH **"the detergent of the atmosphere."**

Because OH controls the lifetime of methane—a powerful greenhouse gas—its future trend is one of the most important questions in climate science.

A major new study by **Liu, Song, Matsui, Shang, Kang, Cai, Zhang, and Zhu** (Nature Communications, 2024) provides the strongest evidence to date that **global OH levels will rise under carbon-neutrality pathways**, but **decline under high-emissions futures**.

This finding has major implications:

- Higher OH → methane removed faster → lower methane warming
- Lower OH → methane removed slower → higher methane warming

The study also shows that OH trends depend on a balance between **sources** (photolysis, NO_x recycling, water vapor) and **sinks** (methane, CO, VOCs). Their key discovery is that **sink strength dominates**: reducing methane and CO increases OH even if ozone and NO_x decline.

This overturns the long-held assumption that climate policies reducing NO_x and ozone would weaken OH.

What Liu et al. Found About OH Trends

1. OH increases under carbon-neutrality (SSP1-26)

Across three major Earth system models, global OH rises **0.071–0.16% per year** from 2015–2100.

Why?

- **Methane decreases ~40%**
- **Carbon monoxide decreases sharply**
- These reductions weaken OH sinks more than OH sources decline

- Water vapor increases slightly enhance OH production
- Net effect: **OH rises globally**

2. OH decreases under high-emissions (SSP3-70)

Under continued fossil fuel use and rising methane emissions, OH falls **0.037–0.15% per year**.

Why?

- Methane nearly doubles
- CO remains high
- OH sinks strengthen
- Even increased water vapor cannot compensate
- Net effect: **OH declines globally**

3. OH trends vary by region

- **Tropics & subtropics:** OH increases up to **30%**
- **Mid-latitudes & polar regions:** OH decreases up to **40%**

4. Methane lifetime responds strongly to OH

- Under carbon neutrality: methane lifetime shortens by **0.19–1.1 years**
- Under high emissions: methane lifetime lengthens by **0.43–1.7 years**

5. Methane radiative forcing changes accordingly

- Carbon neutrality: methane forcing decreases an additional **6–41%** due to OH increases
- High emissions: methane forcing increases **+0.034 to +0.16 W/m²** due to OH decreases

Their conclusion

Sustaining or increasing OH is essential for climate mitigation. Weakening OH under high emissions amplifies methane's warming effect.

PAGE 3 — How ReductionTech's OH\ Dispersal Concept Fits Into This Science*

Liu et al. show that OH can rise naturally when methane and CO sinks decline. But they also show that OH falls sharply when sinks rise or when ozone photolysis weakens.

This is where ReductionTech's **OH*** concept enters the scientific conversation.

What OH\ dispersal proposes*

OH* dispersal is a **hypothetical oxidant-restoration technology** designed to:

- Enhance photolysis-driven OH production
- Strengthen HOx recycling
- Counteract OH suppression caused by aerosols, pollution, or geoengineering
- Reduce methane and CO lifetimes even when emissions remain high
- Stabilize oxidant capacity under conditions where natural OH would decline

How OH\ differs from Liu et al.'s mechanism*

Liu et al. (2024)	ReductionTech OH*
OH increases because sinks decline	OH increases because sources are enhanced
Works only under low-emissions futures	Could work under high-emissions or high-aerosol futures
OH trends are sink-dominated	OH trends are source-dominated
Cannot counteract SAI-induced photolysis suppression	Designed to counteract photolysis suppression

Why OH\ matters scientifically*

Liu et al. show that OH is vulnerable to:

- Rising methane
- Rising CO
- Aerosol shading
- Reduced ozone photolysis
- Declining NOx
- Climate-driven humidity changes

OH* dispersal proposes a way to **restore oxidant capacity** even when these pressures intensify.

Potential benefits of OH*

If scientifically validated, OH* dispersal could:

- Reduce methane lifetime beyond carbon-neutrality levels
- Counteract methane forcing increases under high emissions
- Offset oxidant suppression from stratospheric aerosol injection (SAI)
- Stabilize atmospheric oxidation capacity under heavy pollution
- Provide a chemical mitigation pathway independent of emissions reductions

This is why scenario modeling is essential.

Why Modeling Both Frameworks Together Matters

Liu et al. provide the strongest evidence yet that **OH is a climate lever**. Their work shows that OH trends can either:

- **Accelerate climate mitigation** (if OH rises), or
- **Amplify climate warming** (if OH falls)

ReductionTech's OH* concept proposes a way to **actively manage** this lever.

Why the public should care

Methane is responsible for about **30% of current warming**. Its lifetime is controlled almost entirely by OH. If OH declines, methane accumulates faster. If OH rises, methane declines faster.

This means:

The future of OH is the future of methane. And the future of methane is the future of near-term climate warming.

Why modeling is needed

To understand the full picture, scientists must evaluate:

1. **Natural OH evolution under carbon neutrality**
2. **Natural OH decline under high emissions**
3. **OH suppression under SAI and heavy aerosols**
4. *OH restoration under OH\ dispersal scenarios**

Only by comparing all four can we understand:

- How stable the oxidant system is
- How vulnerable it is to aerosol shading
- How methane forcing will evolve
- Whether oxidant restoration could meaningfully support climate mitigation

The public takeaway

The new science shows that OH is not static. It responds to human activity, climate policy, pollution, and atmospheric chemistry. Strengthening OH—whether naturally through emissions reductions or

artificially through oxidant-restoration concepts—could play a major role in shaping the climate of the 21st century.