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ABLATION AS ABATEMENT? SPACE-DEBRIS MITIGATION, MIDDLE-ATMOSPHERE EMISSIONS AND THE TRIGGER PROBLEM IN ATMOSPHERIC LAW

~ Aviral Joshi & Gyan Prakash Upadhyay

Abstract

Between roughly 12 and 85 kilometres above the Earth, rocket launches and the controlled re-entry of satellites and rocket bodies are introducing black carbon, alumina, chlorine species, nitrogen oxides and ablation metals into the stratosphere and mesosphere. Scientific assessments identify these inputs as an emerging threat to ozone and radiative balance, yet no treaty regulates them and no regulator is responsible for them. This article argues that the usual explanations, namely the undefined boundary of outer space and the pre-environmental origins of space law, are incomplete. Jurisdiction over launches is well established, because the launching State, the State of registry and the licensing State are identifiable. The real obstacle is a trigger problem. Atmospheric regimes are triggered by listed substances or by aircraft, while space regimes are triggered by space objects and concentrate on orbital safety. Launch and re-entry emissions satisfy neither trigger in full. The difficulty is compounded by a contradiction in space-debris mitigation law, which directs operators toward atmospheric disposal and thereby exports a pollution burden to a layer that no rule protects, a pattern described here as ablation as abatement. Using a doctrinal method supported by atmospheric-science literature, the article examines aviation law, the ozone regime, the space treaties and comparative practice in the European Union and the United States. It answers five principal objections, including uncertainty, development and fragmentation. It then proposes a three-tier functional obligation triggered by atmospheric effect rather than by altitude, substance or vehicle type: an interpretive decision under the ozone regime, an annual reporting duty, and domestic licence conditions grounded in Article VI of the Outer Space Treaty. India's

environmental and space legislation is analysed as an implementation model. The proposal closes the gap without awaiting delimitation of outer space and builds the scientific evidence on which stronger obligations may later rest.

Keywords: *Space-debris mitigation; middle-atmosphere emissions; ozone layer; Outer Space Treaty; atmospheric law*

I. Introduction

Between roughly 12 and 85 kilometres above the Earth, the stratosphere and mesosphere are receiving new anthropogenic inputs. Rocket engines deposit black carbon, alumina, chlorine species and nitrogen oxides directly into the ozone layer. Satellites and rocket bodies are increasingly disposed of by controlled re-entry, and their ablation leaves metals and oxides in the same layers. The 2022 WMO/UNEP ozone assessment identified rocket emissions as an emerging concern.¹ Modelling studies indicate that solid-propellant and kerosene-fuelled launches can affect stratospheric ozone and radiative balance,² and radiative forcing from rocket black carbon is disproportionate to its mass because it is released above the tropopause.³ Sampling has found aluminium and other spacecraft-derived metals in stratospheric sulfuric-acid particles.⁴ Projections for large satellite constellations suggest that alumina from re-entry may become a significant ozone-relevant input.⁵

The law's response is thin. No treaty regulates these emissions as such, and no regulator is responsible for them. The usual explanations are that the boundary between airspace and outer space is undefined, or that space law was drafted before environmental law existed. This article argues that both explanations are incomplete. Jurisdiction over launches is well established, since the launching State, the State of registry and the licensing State are all identifiable. The vacuum arises from a *trigger problem*. Atmospheric regimes are triggered by a listed substance

¹World Meteorological Organization, *Scientific Assessment of Ozone Depletion: 2022* (GAW Report No 278, WMO 2022).

²Robert G Ryan and others, 'Impact of Rocket Launch and Space Debris Air Pollutant Emissions on Stratospheric Ozone and Global Climate' (2022) 10 *Earth's Future* e2021EF002612.

³Martin N Ross and Patrick M Sheaffer, 'Radiative Forcing Caused by Rocket Engine Emissions' (2014) 2 *Earth's Future* 177.

⁴Daniel M Murphy and others, 'Metals from Spacecraft Reentry in Stratospheric Aerosol Particles' (2023) 120 *PNAS* e2313374120.

⁵Joseph P Ferreira and others, 'Potential Ozone Depletion from Satellite Demise during Atmospheric Reentry in the Era of Mega-Constellations' (2024) 51 *Geophysical Research Letters* e2024GL109280; see also Aaron C Boley and Michael Byers, 'Satellite Mega-Constellations Create Risks in Low Earth Orbit, the Atmosphere and on Earth' (2021) 11 *Scientific Reports* 10642.

(the Montreal Protocol) or by an activity class (aviation). Space regimes are triggered by a space object and are oriented toward orbital safety. Launch and re-entry emissions are neither listed substances nor aircraft emissions, and the space regime does not treat them as environmental harm. The problem is worsened by a doctrinal contradiction: space-debris mitigation law pushes operators toward atmospheric disposal, so a rule designed to protect orbits systematically transfers pollutants to a layer that no rule protects.

The research question is whether international law, and Indian law as an implementing legal order, regulates middle-atmosphere emissions from launch and re-entry, and, if not, how the gap can be closed without waiting for a delimitation of outer space. The thesis is that the gap can be closed by a functional obligation triggered by *atmospheric effect* rather than by altitude, substance or vehicle type. It would be anchored in Article 2(1) of the Vienna Convention for the Protection of the Ozone Layer and in the State's duty of authorisation and supervision under Article VI of the Outer Space Treaty, and implemented through reporting, assessment and licence conditions. The method is doctrinal, supported by atmospheric-science literature where it establishes the legal facts. Part II sets out the framework, Part III analyses the existing regimes, Part IV draws comparative lessons, Part V tests the thesis against counterarguments, and Part VI proposes reform.

II. Conceptual and Legal Framework

The article uses “middle atmosphere” for the stratosphere and mesosphere. “Airspace pollution” is used in the wider sense of anthropogenic introduction of substances into the atmosphere above national territory. The International Law Commission (ILC) defines the atmosphere as the envelope of gases surrounding the Earth and atmospheric pollution as the human introduction of substances or energy that causes deleterious effects endangering human life and health and the natural environment.⁶ The definition is effect-based and altitude-neutral. The ILC nonetheless expressly excluded outer space, including its delimitation, from the topic.⁷ It also identified the relationship between atmospheric protection and other bodies of law (trade, investment, the law of the sea and human rights) without naming space law.⁸ That silence is the starting point of this article.

⁶ILC, ‘Guidelines on the Protection of the Atmosphere’ in *Report of the International Law Commission* (72nd session, 2021) UN Doc A/76/10, guideline 1.

⁷ILC, *Report of the International Law Commission* (65th session, 2013) UN Doc A/68/10, ch VIII (Understanding on the topic ‘Protection of the atmosphere’).

⁸ILC Guidelines (n 6) guideline 9.

The customary baseline is uncontroversial. A State must not knowingly allow its territory to be used contrary to the rights of other States.⁹ It must not cause significant transboundary harm.¹⁰ It is under a duty of due diligence, including environmental impact assessment where a proposed activity may have a significant transboundary impact.¹¹ The ILC's Draft Articles on Prevention of Transboundary Harm from Hazardous Activities codify prevention and risk assessment.¹² The International Tribunal for the Law of the Sea (ITLOS) in 2024 held that anthropogenic greenhouse-gas emissions into the atmosphere constitute pollution of the marine environment under UNCLOS.¹³ The International Court of Justice's 2025 advisory opinion on climate change confirmed that States have customary and treaty obligations to protect the climate system, that due diligence is stringent, and that breach engages State responsibility.¹⁴

These principles supply the *duty* but not the *standard*. Due diligence is a variable obligation whose content depends on available scientific knowledge and on institutions that translate that knowledge into thresholds. Customary law does not by itself say what quantity of alumina in the stratosphere is unlawful. It therefore needs conventional and institutional support, which is where the fragmentation arises.

Two families of regime are relevant. *Activity-triggered* regimes apply because a particular kind of conduct occurs. The Chicago Convention applies to "aircraft" and gives each State complete and exclusive sovereignty over the airspace above its territory,¹⁵ and the space treaties apply to "space objects" and activities in "outer space". *Substance- or effect-triggered* regimes apply because a specified pollutant is present or a specified effect arises. The Vienna Convention and the Montreal Protocol regulate ozone-depleting substances,¹⁶ the UNFCCC regulates

⁹*Corfu Channel Case (United Kingdom v Albania)* (Merits) [1949] ICJ Rep 4, 22.

¹⁰*Trail Smelter Case (United States v Canada)* (Awards, 1938 and 1941) 3 RIAA 1905, 1965; Stockholm Declaration (1972) UN Doc A/CONF.48/14/Rev.1, principle 21; Rio Declaration (1992) UN Doc A/CONF.151/26 (Vol I), principle 2; *Legality of the Threat or Use of Nuclear Weapons (Advisory Opinion)* [1996] ICJ Rep 226 [29].

¹¹*Pulp Mills on the River Uruguay (Argentina v Uruguay)* (Judgment) [2010] ICJ Rep 14 [101], [204]; *Certain Activities Carried Out by Nicaragua in the Border Area (Costa Rica v Nicaragua)* (Judgment) [2015] ICJ Rep 665 [104].

¹²ILC, 'Draft Articles on Prevention of Transboundary Harm from Hazardous Activities' [2001] YILC vol II(2) 148, arts 3 and 7.

¹³*Request for an Advisory Opinion Submitted by the Commission of Small Island States on Climate Change and International Law* (Case No 31, ITLOS, Advisory Opinion, 21 May 2024) [179].

¹⁴*Obligations of States in respect of Climate Change* (Advisory Opinion, ICJ, 23 July 2025).

¹⁵Convention on International Civil Aviation (adopted 7 December 1944, entered into force 4 April 1947) 15 UNTS 295 (Chicago Convention) art 1.

¹⁶Vienna Convention for the Protection of the Ozone Layer (adopted 22 March 1985, entered into force 22 September 1988) 1513 UNTS 293; Montreal Protocol on Substances that Deplete the Ozone Layer (adopted 16 September 1987, entered into force 1 January 1989) 1522 UNTS 3.

greenhouse gases,¹⁷ and the Convention on Long-Range Transboundary Air Pollution, which is regional, regulates air pollutants in the UNECE area.¹⁸ Middle-atmosphere emissions from launch and re-entry pass through the seam between these two families.

III. Critical Analysis of the Existing Framework

A. Aviation law: regulation by vehicle class

The Chicago Convention system does regulate emissions, through Annex 16 to the Convention. Volume II governs engine emissions, Volume III the aircraft CO₂ standard, and Volume IV the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).¹⁹ The ICAO Assembly has also adopted a long-term aspirational goal of net-zero carbon emissions from international aviation by 2050.²⁰ Three limitations matter here. First, the regime attaches to “aircraft”, which ICAO’s Annexes define by reference to support derived from the reactions of the air.²¹ A launch vehicle, which does not, falls outside the definition. Second, CORSIA addresses CO₂ from international flights and does not reach non-CO₂ effects, in particular contrails and NO_x-induced effects, which are outside its offsetting design. Third, the ICAO structure rests on consensus among States with divergent interests and on the principle of differentiation. India, for example, has not participated in the voluntary phases of CORSIA, invoking common but differentiated responsibilities and respective capabilities.²² The aviation regime is therefore itself incomplete for the upper troposphere and lower stratosphere, and it has no application to rockets.

B. The ozone regime: regulation by list

Article 2(1) of the Vienna Convention obliges parties to take appropriate measures to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer.²³ The obligation is

¹⁷United Nations Framework Convention on Climate Change (adopted 9 May 1992, entered into force 21 March 1994) 1771 UNTS 107.

¹⁸Convention on Long-Range Transboundary Air Pollution (adopted 13 November 1979, entered into force 16 March 1983) 1302 UNTS 217, art 1(a).

¹⁹ICAO, *Annex 16 to the Convention on International Civil Aviation: Environmental Protection*, vols II, III and IV.

²⁰ICAO Assembly, 41st Session (2022), Resolution A41-21.

²¹ICAO, *Annex 7 to the Chicago Convention* (Aircraft Nationality and Registration Marks), definitions.

²²ICAO, list of States participating in CORSIA; for the differentiation debate see Lavanya Rajamani, *Differential Treatment in International Environmental Law* (OUP 2006).

²³Vienna Convention (n 16) arts 1(2), 2(1).

framed by *activity and effect*, not by substance, and is indifferent to altitude of origin. Its operational content, however, was delegated to the Montreal Protocol, which controls specified chemicals listed in its annexes.²⁴ Alumina, black carbon and nitrogen oxides from launch and re-entry are not controlled substances. Adding a substance requires an amendment to the Protocol, and adjustments under Article 2(9) operate on substances already controlled. The Protocol's institutional strength, in its scientific assessment panels (Article 6) and its data-reporting duties (Article 7), is therefore tied to the list.²⁵ The consequence is that the Convention's broad obligation has never been operationalised for launch and re-entry, although its text does not exclude them. Article 2(2) contemplates cooperation in adopting agreed measures, procedures and standards with a view to protocols, and Article 8 provides the protocol-making mechanism.²⁶

C. Space law: regulation by object, with the environment as an afterthought

The Outer Space Treaty imposes international responsibility on States for national space activities, including those of non-governmental entities, and requires that such activities be authorised and continually supervised by the appropriate State.²⁷ Article VII makes the launching State liable for damage caused by space objects.²⁸ The environmental clause in Article IX is directed elsewhere. It requires States to conduct exploration so as to avoid harmful contamination of outer space and celestial bodies, and adverse changes in the Earth's environment resulting from the introduction of *extraterrestrial* matter.²⁹ Launch effluent and re-entry debris are of terrestrial origin, so the text does not fit them.

The Liability Convention imposes absolute liability for damage caused by a space object on the surface of the Earth or to aircraft in flight.³⁰ "Damage" is defined as loss of life, personal injury or other impairment of health, or loss of or damage to property.³¹ Canada's 1979 claim against the USSR for the radioactive debris of Cosmos 954 relied on the Convention and on

²⁴Montreal Protocol (n 16) art 2 and annexes.

²⁵*ibid* arts 6, 7, 2(9).

²⁶Vienna Convention (n 16) arts 2(2), 8.

²⁷Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (adopted 27 January 1967, entered into force 10 October 1967) 610 UNTS 205 (Outer Space Treaty) art VI.

²⁸*ibid* art VII.

²⁹*ibid* art IX.

³⁰Convention on International Liability for Damage Caused by Space Objects (adopted 29 March 1972, entered into force 1 September 1972) 961 UNTS 187, art II.

³¹*ibid* art I(a).

general principles of international law, including the principle that a State must not cause harm through activities in its jurisdiction, in seeking the costs of clean-up. The USSR paid C\$3 million in a 1981 settlement, without conceding the legal basis.³² The episode shows that States will negotiate environmental damage from space activities. It falls short of establishing that diffuse, cumulative atmospheric modification is compensable “damage” under the Convention, because the harm is neither localised nor readily attributable to a single object.

Space-debris mitigation law then supplies the contradiction. The COPUOS Space Debris Mitigation Guidelines, endorsed by the General Assembly, call on operators to limit the long-term presence of spacecraft and launch-vehicle stages in low-Earth orbit after end of mission.³³ The 2019 Guidelines for the Long-term Sustainability of Outer Space Activities continue that orientation.³⁴ National measures go further: the US Federal Communications Commission now requires certain low-Earth-orbit satellites to be disposed of within five years of mission end.³⁵ The practical means of compliance is deorbit and atmospheric burn-up. Each of these instruments treats disposal by re-entry as the solution and none treats the resulting ablation products as an emission. A legal regime that rewards atmospheric disposal without accounting for the atmosphere is, in effect, *ablation as abatement*: it improves orbital conditions by exporting a pollution burden downward.

D. The consequence: a regulatory seam

The result is not that no rules exist. It is that each regime’s trigger is satisfied only in part. The aviation regime is triggered by aircraft but not by rockets. The ozone regime is triggered by listed substances but not by launch by-products. The climate regime is triggered by greenhouse gases and largely ignores short-lived climate forcings such as black carbon. The space regime is triggered by space objects but frames environmental harm as contamination of *space*. General international law supplies duties but no standards. The vacuum is thus produced by the interaction of regimes rather than by silence in any one of them. That diagnosis matters for the

³²Canada: Claim against the Union of Soviet Socialist Republics for Damage Caused by Soviet Cosmos 954’ (1979) 18 ILM 899; Protocol on Settlement of Canada’s Claim (1981) 20 ILM 689.

³³UNGA Res 62/217 (22 December 2007) UN Doc A/RES/62/217, endorsing the COPUOS Space Debris Mitigation Guidelines, guideline 6.

³⁴COPUOS, ‘Guidelines for the Long-term Sustainability of Outer Space Activities’ (2019) UN Doc A/74/20, annex II.

³⁵FCC, *Space Innovation; Mitigation of Orbital Debris in the New Space Age*, Second Report and Order, FCC 22-74 (29 September 2022).

remedy: since jurisdiction over launch and re-entry is not in doubt, reform need not wait for the definition and delimitation of outer space.

IV. Comparative and Interdisciplinary Analysis

The European Union. The EU has moved on aviation. Directive (EU) 2023/958 amended the Emissions Trading System to extend monitoring, reporting and verification to aviation's non-CO₂ effects.³⁶ In June 2025 the Commission also proposed an EU Space Act that would place safety, resilience and sustainability obligations on space operators, including an environmental-footprint dimension.³⁷ The two instruments show that the trigger problem can be solved legislatively, by reporting duties on operators of a defined activity, but they operate at the regional level and their scope and final form remain matters of legislative negotiation.

The United States. US launch and re-entry licensing lies with the Federal Aviation Administration under the Commercial Space Launch Activities statute,³⁸ and the environmental review required for a licence falls under the National Environmental Policy Act (NEPA).³⁹ NEPA is a procedural instrument. It requires disclosure of significant effects but prescribes no emission standard, and the Supreme Court's 2025 decision in *Seven County Infrastructure Coalition v Eagle County* emphasised judicial deference to agencies on the scope of that review.⁴⁰ The US model therefore has a licensing hook but no substantive atmospheric standard, so the gap remains in the world's largest launch jurisdiction.

The ozone regime as a procedural template. The instructive comparison is with the Montreal Protocol's own architecture. Its success owes as much to its procedural machinery as to its control schedule: periodic scientific assessment, mandatory data reporting, and a mechanism for adjusting obligations as evidence develops.⁴¹ That machinery transfers readily to a new class of activity. It does not require agreement on precise emission limits at the outset. It requires agreement on *measurement*, and measurement is what the launch and re-entry sector currently lacks.

³⁶Directive (EU) 2023/958 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC [2023] OJ L130/115.

³⁷European Commission, Proposal for a Regulation on the safety, resilience and sustainability of space activities in the Union (EU Space Act) COM(2025) 335 final.

³⁸51 USC ch 509 (Commercial Space Launch Activities).

³⁹National Environmental Policy Act 1969, 42 USC § 4321 et seq.

⁴⁰*Seven County Infrastructure Coalition v Eagle County, Colorado* 605 US ____ (2025).

⁴¹Montreal Protocol (n 16) arts 6, 7; Daniel Bodansky, *The Art and Craft of International Environmental Law* (Harvard UP 2010).

Atmospheric science as a legal input. The scientific literature is uncertain on magnitude but consistent on direction and mechanism. Because the science is preliminary, it supports a legal architecture built around assessment and reporting, which generates evidence and allows obligations to be calibrated later, more than one built around early emission caps. Legal design should follow the state of the evidence in that way.

The Global South. Launch activity is concentrated in a few States, while the ozone layer and radiative balance are global commons whose degradation would fall heavily on States that have contributed nothing to the burden. Yet developing States with emerging space programmes, India foremost among them, have an interest in not being locked out of space access by burdens imposed by incumbents. The Indian position is thus double-edged, as launching State and as Global South advocate, and it is analysed in Part VI.

V. The Central Legal Problem: Objections and Responses

Objection 1: existing law already suffices. The strongest version of this view holds that Article 2(1) of the Vienna Convention, the no-harm rule, and Article VI of the Outer Space Treaty already impose the necessary obligations, so no new instrument is needed.⁴² The response is that this is correct as to *duty* and mistaken as to *effectiveness*. The prevention duty is enforceable only after significant transboundary harm is demonstrated, and it requires a causal chain that diffuse stratospheric effects make evidentially difficult. General duties lack the reporting, assessment and standard-setting machinery that turns due diligence from an abstraction into a measurable obligation. The ICJ's 2025 opinion affirms the stringency of due diligence but, being general, cannot specify the standard for a particular emission class.

Objection 2: the science is too uncertain. Regulating on modelling projections, it may be said, risks acting on speculation. The precautionary principle addresses this: where there is a threat of serious or irreversible damage, lack of full scientific certainty should not be used to postpone cost-effective measures.⁴³ The proposal here also does not rest on precaution alone. It is deliberately confined to assessment and reporting, which are the least intrusive precautionary measures and are designed to remove the uncertainty that the objection identifies.

⁴²cf Patricia Birnie, Alan Boyle and Catherine Redgwell, *International Law and the Environment* (4th edn, OUP 2021) ch 5 (on general duties of prevention).

⁴³Rio Declaration (n 10) principle 15.

Objection 3: delimitation must come first. Any atmospheric rule for the middle atmosphere, on this view, must be preceded by agreement on where airspace ends. This mistakes the level at which the problem arises. Vienna Convention Article 2(1) and the ILC's effect-based definition are indifferent to altitude. The relevant legal facts, launching State, State of registry and licensing State, are altitude-independent. A functional approach thus avoids the boundary question entirely, and can be adopted without prejudice to delimitation.

Objection 4: development and access. A regime that burdens launch and re-entry could entrench the advantage of established space powers and impose compliance costs on emerging ones. The objection has force, and the design in Part VI addresses it through differentiated reporting capacity, a phased approach, and a research-first structure that imposes no substantive limits until the assessment process has established a scientific basis. Differentiation is consistent with the Vienna Convention's own approach and with the principle of common but differentiated responsibilities as developed for the ozone regime.⁴⁴

Objection 5: fragmentation and institutional overlap. Placing the subject under the ozone institutions risks competing claims by ICAO, UNOOSA and COPUOS. The proposal responds by using the ILC's approach to fragmentation. Treaty provisions are to be interpreted in light of "any relevant rules of international law applicable in the relations between the parties" (VCLT Article 31(3)(c)), which enables systemic integration between the space treaties and the ozone regime.⁴⁵ Article VI of the Outer Space Treaty, read with Article 2(1) of the Vienna Convention, yields a coherent single obligation: a State that authorises a launch or re-entry must consider its likely effects on the ozone layer.

VI. Proposed Legal Framework

The proposal has three tiers, ordered by political feasibility.

Tier 1: an interpretive decision under the ozone regime. The Meeting of the Parties to the Vienna Convention and the Montreal Protocol should adopt a decision recognising that launch and re-entry emissions are "human activities" within Article 2(1), and instructing the assessment panels under Article 6 of the Protocol to evaluate their effects. A decision of this kind creates no new binding controls. It secures institutional recognition and generates the

⁴⁴Rajamani (n 22).

⁴⁵Vienna Convention on the Law of Treaties (adopted 23 May 1969, entered into force 27 January 1980) 1155 UNTS 331, art 31(3)(c); ILC, *Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law* (Report of the Study Group, 13 April 2006) UN Doc A/CN.4/L.682.

science on which any later control would depend. It also reflects existing treaty text, so it does not require treaty amendment or delimitation.

Tier 2: a reporting obligation. Launching States should report annually, by analogy to the Article 7 data-reporting model, the mass and type of propellant used, altitude-resolved emissions to the extent estimable, and the mass and composition of re-entering objects. The obligation could be introduced by decision in the first instance and consolidated later in a protocol under Article 8 of the Vienna Convention. To meet the concerns of emerging space States, reporting duties should be phased and supported by technical assistance, on the model of differentiated implementation in the ozone regime.

Tier 3: domestic licence conditions as the treaty-mandated implementation route. Article VI of the Outer Space Treaty already requires authorisation and continuing supervision of non-governmental space activity. States should embed an *atmospheric-effects assessment* in launch and re-entry licences, requiring operators to assess and report emissions and to consider disposal alternatives. COPUOS could adopt this as a guideline alongside its existing sustainability guidelines. Domestic licence conditions are the most feasible tier because they require no new treaty and sit within existing State discretion.

The Indian dimension. India is a party to the Outer Space Treaty and the Liability Convention and is an active launching State, and its domestic law is well placed to implement this design. The Air (Prevention and Control of Pollution) Act 1981 defines “air pollutant” as any solid, liquid or gaseous substance present in the atmosphere in concentrations that may be injurious to human beings, other living creatures, plants, property or the environment.⁴⁶ That definition is not limited by altitude, and the Act extends to the whole of India.⁴⁷ Its enforcement machinery, in particular consent for industrial plant in air-pollution-control areas, is site-based and does not sit easily with atmospheric effects above the launch site.⁴⁸ The Environment (Protection) Act 1986 supplies the wider power. Section 3(2)(iv) authorises the Central Government to lay down standards for emission or discharge of environmental pollutants from various sources whatsoever,⁴⁹ and that power is sufficient to prescribe emission-reporting requirements for launch operations.

⁴⁶ Air (Prevention and Control of Pollution) Act 1981, s 2(a).

⁴⁷ *ibid* s 1(2).

⁴⁸ *ibid* ss 19, 21.

⁴⁹ Environment (Protection) Act 1986, ss 3(2)(iv), 6.

Constitutional doctrine supports this route. The Supreme Court has held that the right to life under Article 21 includes the right to a pollution-free environment,⁵⁰ and that the precautionary and polluter-pays principles are part of India's environmental law.⁵¹ The Court has also applied absolute liability to hazardous industrial activity.⁵² Parliament may legislate to implement international obligations under Article 253, and the Union has legislative competence over air navigation under Entry 29 of List I.⁵³ Institutionally, the Indian Space Policy 2023 assigns authorisation of non-governmental space activity to IN-SPACe,⁵⁴ and the long-awaited space-activities legislation would be the natural vehicle for an atmospheric-effects condition. The National Green Tribunal, which has jurisdiction over substantial environmental questions arising under the Air Act and the Environment (Protection) Act, would supply the adjudicative forum.⁵⁵

For India the policy argument is also strategic. By adopting a modest, evidence-generating framework voluntarily, India would occupy the position of a Global South launching State that shapes the standard rather than receiving it. That would allow it to press for differentiated obligations from within the process, which is more effective than the position it has taken in the CORSIA context, where non-participation has left it outside the standard-setting conversation.⁵⁶

Anticipated objections to the design. A sovereignty objection holds that emissions reporting intrudes on States' control over their space programmes. The response is that reporting concerns effects on a global commons, involves no inspection of the space programme, and is consistent with State practice in the ozone regime. A treaty-conflict objection holds that ozone institutions lack competence over space activities. The answer is that the Vienna Convention's obligation is activity-based and effect-based by its own terms, and that VCLT Article 31(3)(c) permits the integrated reading proposed. An enforcement objection points to the absence of a compliance mechanism. That is a fair criticism, and the design meets it by starting with transparency, the Montreal Protocol's own foundation, and by relying on State responsibility as the residual enforcement route once standards develop.

⁵⁰*Subhash Kumar v State of Bihar* (1991) 1 SCC 598.

⁵¹*Vellore Citizens Welfare Forum v Union of India* (1996) 5 SCC 647.

⁵²*MC Mehta v Union of India* (1987) 1 SCC 395.

⁵³Constitution of India, art 253; Seventh Schedule, List I, entry 29.

⁵⁴Department of Space, Government of India, *Indian Space Policy 2023* (April 2023).

⁵⁵National Green Tribunal Act 2010, ss 14 and Schedule I.

⁵⁶ICAO, CORSIA participation lists (n 22).

VII. Conclusion

The research question asked whether international and Indian law regulate middle-atmosphere emissions from launch and re-entry, and how any gap should be closed. The answer is that they do not, in any operational sense, and that the reason lies in the way regulatory triggers are constructed. The atmospheric regimes are triggered by substance or by aircraft, and the space regime is triggered by space objects and treats environmental harm as a matter of contaminating space. Debris-mitigation law compounds the problem by directing operators to atmospheric disposal without accounting for what disposal releases. The existing framework contains the necessary duties (Article 2(1) of the Vienna Convention, Article VI of the Outer Space Treaty, and customary prevention and due diligence) but lacks the machinery of assessment, reporting and licensing conditions that would give them content.

The article's contribution is to reframe the vacuum as a trigger mismatch, which removes the apparent need to resolve the delimitation of outer space, and to propose a tiered functional solution that begins with an interpretive decision and reporting, proceeds through licence conditions under Article VI of the Outer Space Treaty, and uses India's domestic framework as a workable implementation model. The proposal is deliberately modest in its substantive demands, because the science is still developing, and deliberately structured to generate the evidence on which stronger obligations could later rest. It does not claim that current law already prohibits launch and re-entry emissions. It claims that the law should be developed so that the atmosphere is protected against them, whichever regime the polluting activity belongs to.