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The Unmonitored Sky

Paper VII: Earth's Atmospheric Commons and the Geoengineering Governance Vacuum

Independent Global Systems Policy Research | May 2026 | Paper VII

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Humanity is conducting an uncontrolled experiment on its own atmosphere. Stratospheric aerosol injection programs are being researched and piloted by independent actors. Solar radiation management field tests have been conducted without international consent. Carbon capture technologies are being deployed at scale with no aggregate climate modeling requirement. Meanwhile, the atmospheric commons — the shared gaseous envelope that regulates temperature, shields life from radiation, and sustains every ecosystem on Earth — has no binding global governance architecture. This paper applies the Fair Framework diagnostic to the planetary atmosphere: identifying the system, the chokehold, the governance vacuum, the cascading risk, and the minimum viable institutional response before an irreversible threshold is crossed.

PAPER VII | THE FAIR FRAMEWORK SERIES

The Unmonitored Sky:

Earth's Atmospheric Commons and the Geoengineering Governance Vacuum

How Stratospheric Aerosol Injection, Solar Radiation Management, and Unilateral Atmospheric Interventions Are Racing Ahead of Any Binding Global Governance — With Irreversible Consequences if They Fail

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ABSTRACT

The Experiment Already Underway

The planetary atmosphere is the most fundamental commons on Earth — the shared gaseous envelope that regulates surface temperature, filters solar radiation, distributes precipitation, and sustains every ecosystem from the deep ocean to the upper canopy. It is also the planetary system most urgently and recklessly being acted upon without aggregate governance.

Stratospheric aerosol injection (SAI) — the deliberate release of reflective particles into the upper atmosphere to reduce incoming solar radiation — has moved from theoretical proposal to active field experimentation. Solar radiation management (SRM) programs are being funded, researched, and in some cases piloted by universities, private entities, and national programs operating under no binding international framework. Carbon dioxide removal technologies are being deployed at scale with no requirement to model their cumulative atmospheric effect. And the existing international governance architecture — built on voluntary pledges, non-binding accords, and siloed domain-specific agreements — is constitutionally incapable of seeing the atmospheric system as a whole.

The Fair Framework diagnostic applied here identifies five compounding failures: the atmospheric system itself, the chokehold of unilateral actors, the governance vacuum that permits them, the cascading risks of uncoordinated intervention, and the minimum viable institutional response. The window for governance is open. The physics will not wait for political consensus.

The System: Earth's Atmosphere as Planetary Commons

The atmosphere is a planetary commons in the most literal sense: a shared, finite, and physically integrated system whose properties determine the habitability of the entire surface of the Earth. It is not divisible by national borders. It does not recognize jurisdictional authority. What enters it in one location circulates globally within weeks. What is removed from it in one region affects precipitation patterns,

temperature gradients, and agricultural viability across continents.

Three atmospheric subsystems are of particular governance relevance to this paper: the troposphere, which governs weather and surface temperature and where greenhouse gas concentrations are increasing; the stratosphere, the target of proposed geoengineering interventions, where aerosol loading affects the ozone layer and global albedo; and the mesosphere and thermosphere, where increasing satellite reentry and ablation from mega-constellations is depositing novel metallic compounds at altitudes with no baseline monitoring.

What distinguishes the atmosphere from every other commons examined in this series is the speed and irreversibility of potential tipping dynamics. Kessler Syndrome in orbit is irreversible on human timescales. Aquifer depletion takes decades to become catastrophic. Atmospheric tipping points — the collapse of the Atlantic Meridional Overturning Circulation, the destabilization of the Indian monsoon system, the runaway albedo feedback from Arctic ice loss — can cascade within years once triggered, and cannot be reversed by any technology currently available or on any foreseeable development horizon.

◆ KEY FINDING

The 2022 IPCC Sixth Assessment Report identified five 'low-likelihood, high-impact' climate tipping points that could be triggered at current or near-term warming levels, including West Antarctic Ice Sheet collapse, Greenland Ice Sheet disintegration, tropical coral reef die-off, boreal permafrost abrupt thaw, and AMOC weakening. Each represents an irreversible threshold beyond which atmospheric intervention becomes remediation of permanent damage rather than prevention of it. None are subject to a binding international governance framework that explicitly manages cumulative human contributions toward these thresholds.

II The Chokehold: Unilateral Actors in a Governance Vacuum

Unlike the food supply or orbital space, the atmospheric commons has no dominant corporate chokehold. The governance failure here is more dangerous: the chokehold is held by sovereign actors and well-funded research institutions operating in a legal vacuum, each individually convinced of the legitimacy of their intervention, none accountable for aggregate consequences.

Categories of Atmospheric Intervention

■ **Stratospheric Aerosol Injection (SAI):**

The deliberate release of sulfur dioxide or calcium carbonate particles into the stratosphere at altitudes of 15–25 km to reflect incoming solar radiation. Harvard's SCoPEx program, now defunct after public controversy, was among the first to propose stratospheric field trials. Multiple national programs — including research funded by NOAA and pursued independently in the UK, China, and Russia — are in active development. A single nation deploying SAI at scale would alter global precipitation patterns, potentially collapsing monsoon systems on which billions of people depend, with no legal mechanism to prevent or redress it.

■ **Solar Radiation Management (SRM):**

A broader category including marine cloud brightening (seeding low clouds with sea salt to increase their reflectivity), cirrus cloud thinning, and space-based reflectors. Marine cloud brightening field experiments have already been conducted off the coast of California and in Australian waters without binding international review. Each intervention modifies regional and potentially global radiation budgets in ways that current models cannot fully predict — and that no international body is mandated to monitor.

■ **Greenhouse Gas Removal (GGR) at Scale:**

Direct air capture, enhanced ocean alkalinity, afforestation at continental scale, and bioenergy with carbon capture and storage (BECCS) are being deployed and planned at scales that will materially affect atmospheric composition and regional hydrological cycles. No binding protocol requires cumulative atmospheric impact modeling across all deployed GGR technologies simultaneously.

■ **Satellite Reentry and Atmospheric Metallic Contamination:**

As Paper V documented, satellite mega-constellations are creating an orbital congestion crisis. Their reentry — deliberate or uncontrolled — ablates satellite bodies and deposits aluminum, lithium, and other metallic compounds in the mesosphere and upper stratosphere. A 2023 study found that reentry of current Starlink satellites alone deposits approximately 30 metric tons of aluminum oxide annually into the upper atmosphere. The cumulative chemical effect on stratospheric ozone chemistry is unstudied at the system level.

■ **Aviation and Contrail Forcing:**

Commercial aviation generates persistent contrail cirrus clouds that contribute to radiative forcing at a magnitude potentially comparable to the cumulative CO■ contribution of the entire history of aviation. Contrail forcing is highly uncertain in existing climate models and is not included in most national climate accounting frameworks. No international body tracks cumulative contrail radiative forcing against a planetary atmospheric budget.

◆ STRUCTURAL GAP

The institutional architecture of international climate governance is organized around emissions accounting — tracking what enters the atmosphere from below. No mechanism exists to evaluate what is being deliberately injected into, extracted from, or modified within the atmosphere from above. The governance architecture sees the symptom. It is structurally blind to the intervention.

III The Governance Vacuum

The existing international architecture for atmospheric governance is the most elaborately studied governance failure in this entire series — because it is the most publicly visible. The United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement, the Kyoto Protocol, the Montreal Protocol, and the Vienna Convention collectively represent the most extensive international environmental treaty architecture ever assembled. And yet the governance vacuum in the planetary atmosphere is more severe than in any other system this series has examined.

The reason is not the absence of treaties. It is the absence of a mandate to see the atmospheric system as an integrated whole — and particularly to govern deliberate intervention in it.

BODY	COVERS	CRITICAL GAP
UNFCCC / Paris Agreement	Emissions reduction pledges; temperature targets	No binding enforcement; no geoengineering mandate; no aggregate tipping-point governance
Montreal Protocol	Ozone-depleting substances	Does not cover SAI aerosols; no stratospheric intervention authority
UNEP	Environmental coordination; voluntary guidelines	No binding authority; cannot mandate monitoring or halt field tests
WMO	Weather monitoring; climate data standards	No mandate over geoengineering; no cumulative intervention assessment
IPCC	Scientific assessment; risk synthesis	Advisory only; no governance authority; no real-time monitoring mandate

The geoengineering gap is the most acute. No international treaty, protocol, or binding resolution governs who may conduct stratospheric aerosol injection experiments, at what scale, with what prior

consent from affected nations, or with what liability for consequences. The Convention on Biological Diversity passed a non-binding moratorium on geoengineering in 2010 — which the United States, not a party to the CBD, ignored. No successor governance has been established. Meanwhile, the scientific and commercial momentum behind SAI research is accelerating.

> *"The atmosphere is a shared commons. Any unilateral attempt to modify it at scale — however well-intentioned — is an act of intervention in the climate of every nation on Earth. We have no institution mandated to prevent it, assess it, or respond to it."*

IV The Cascading Risk

The atmospheric commons presents a risk structure unlike any other system in this series. In orbital space, the failure mode — Kessler Syndrome — is catastrophic but geographically confined to specific altitude bands. In the planetary atmosphere, the failure modes are civilizationally systemic and cross-domain:

■ **Termination Shock:**

The most acute near-term risk of SAI deployment. If a nation or coalition begins injecting stratospheric aerosols at a scale sufficient to materially reduce surface temperatures, and then stops abruptly — due to political disruption, economic collapse, or conflict — the masking effect disappears rapidly while the accumulated greenhouse gases remain. The result is a temperature rebound potentially 10x faster than the underlying warming rate, against which no ecosystem or agricultural system could adapt in time. Termination shock is the atmospheric equivalent of Kessler Syndrome: a cascading irreversibility triggered by the intervention itself.

■ **Monsoon Disruption:**

Regional SAI deployment — particularly if conducted unilaterally by northern hemisphere nations — could suppress the temperature gradients that drive the South Asian and African monsoon systems. A 2018 modeling study found that hemispheric-asymmetric SAI deployment could reduce Sahel and South Asian monsoon rainfall by 5–15%, threatening water and food security for over 2 billion people. No consent mechanism exists. No liability framework applies.

■ **Ozone Layer Interaction:**

Sulfur dioxide aerosols in the stratosphere catalyze ozone-depleting chemical reactions. Large-scale SAI deployment could delay ozone layer recovery by decades — re-exposing populations to elevated UV radiation and undermining the most successful international environmental treaty in history, the Montreal Protocol, through a mechanism that protocol was never designed to govern.

■ **Compounding with Tipping Points:**

The IPCC has identified that tipping elements interact — that crossing one threshold increases the probability of crossing adjacent ones. Geoengineering interventions that alter precipitation patterns, radiation budgets, or ocean heat uptake could advance rather than retard tipping cascades in ways that no current model has the resolution to predict. The margin for error is zero. The governance architecture is absent.

■ **Atmospheric Metallic Loading:**

The cumulative deposition of aluminum oxide, lithium compounds, and other metallic byproducts from satellite reentry into the upper atmosphere is an unstudied variable being added to an atmosphere already under stress. At current and projected launch and reentry rates, mesospheric metallic concentrations will reach levels with no historical analog within this decade. No baseline exists. No monitoring is mandated. No cap has been proposed.

◆ **KEY FINDING — 2024**

A peer-reviewed analysis published in Nature Climate Change (2024) modeled the risk of 'free-driver' dynamics in geoengineering governance — scenarios in which a single nation or wealthy actor deploys SAI unilaterally because the cost of deployment is low relative to the perceived benefit to that actor, even if aggregate global consequences are highly uncertain or negative for other regions. The study concluded that the cost asymmetry virtually guarantees unilateral deployment in the absence of binding international governance — not as a worst-case scenario, but as a rational equilibrium outcome.

V Proposed Institutional Architecture

The Fair Framework does not propose the cessation of geoengineering research. It proposes the minimum viable institutional architecture to ensure that research, field testing, and eventual deployment — if collectively sanctioned — occurs within a framework that can see the whole atmospheric system, assess cumulative consequences, and maintain the capacity for course correction before irreversible thresholds are crossed.

NO.	INSTITUTION	MANDATE
I	**Planetary Atmospheric Baseline Observatory (PABO)**	A mandated, multi-station, internationally coordinated body for continuous stratospheric and mesospheric monitoring — tracking aerosol loading, ozone column, albedo variation, metallic compound deposition, and contrail radiative forcing against verified baselines. Synthesis mandate required: no siloed national reporting.
II	**Cumulative Atmospheric Intervention Assessment (CAIA) Protocol**	A new class of environmental review — binding on all signatory nations — requiring any large-scale atmospheric intervention (SAI field test, marine cloud brightening deployment, continental-scale GGR program) to model its cumulative contribution to the planetary atmospheric budget across temperature, precipitation, ozone, and albedo dimensions before authorization.
III	**International Geoengineering Governance Treaty (IGGT)**	A binding international agreement — negotiated through a formal Conference of the Parties mechanism under UNEP authority — establishing: (1) a moratorium on unilateral SAI deployment above defined threshold scales; (2) a mandatory prior consent protocol for field experiments affecting transboundary atmospheric systems; (3) binding liability standards for termination shock and monsoon disruption; and (4) a collective sanctioning mechanism for deployment that meets agreed scientific criteria.
IV	**Cross-Domain Atmospheric Synthesis Mandate**	A formal periodic requirement — potentially through WMO and UNEP jointly — for cross-domain synthesis reports aggregating findings from climate science, stratospheric chemistry, ocean-atmosphere interaction, geoengineering modeling, and satellite reentry chemistry into a unified assessment of the atmospheric system's state and trajectory. To be published on a five-year cycle aligned with IPCC assessment timelines.

> *"The atmosphere does not recognize the jurisdictional fictions of sovereign states. What is injected into it belongs to all of us. What is done to it is done to all of us. Governing it requires us to act as if that is true — before the physics proves it for us."*

VI A Note on Authorship and Method

Robert Thomas Fair Jr. is the nephew of Bill Fair — co-founder of FICO, the global credit scoring system that transformed how financial risk is measured, standardized, and governed across borders. The intellectual inheritance is not coincidental.

FICO did not eliminate financial risk. It made risk visible, measurable, and therefore manageable at scale. The Fair Framework applies the same instinct to planetary systems: not to eliminate human activity within them, but to make cumulative risk visible, measurable, and therefore subject to rational governance before it compounds beyond correction.

The atmospheric commons is the most urgent application of this principle. Unlike aquifer depletion, which compounds over decades, or orbital congestion, which accumulates over years, atmospheric tipping dynamics can cascade within years of threshold crossing — at which point no institution, however well-designed, can restore what the physics has already decided.

> *"You cannot manage what you cannot measure. You cannot measure what no institution is mandated to see. And you cannot course-correct what no treaty gives you authority to govern."*

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Robert Thomas Fair Jr. Nephew of Bill Fair — Co-Founder of FICO

The Fair Framework: Seven Papers in Planetary Governance | May 2026

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