STRATOSPHERIC AEROSOL INJECTION – SCIENCE AND TECHNOLOGY

NEWS: A new study published in '**Earth's Future**' explores a **cost-effective approach to Stratospheric Aerosol Injection (SAI)**, a form of **solar geoengineering aimed at cooling the Earth.**

WHAT'S IN THE NEWS?

Stratospheric Aerosol Injection (SAI): Overview

1. **Definition and Technique**
   – SAI is a **geoengineering method** that involves deliberately injecting **reflective particles**—typically sulphur dioxide (SO_2)—into the **stratosphere** to reflect incoming solar radiation and reduce global temperatures.

2. **Natural Analogy**
   – The idea is inspired by **natural volcanic eruptions**, such as the **1991 Mount Pinatubo eruption**, which released large amounts of SO_2 into the stratosphere, leading to **temporary global cooling** of about 0.5°C.

3. **Climate Intervention Role**
   – SAI is considered a **temporary climate intervention** tool meant to **complement** but **not replace** greenhouse gas emission reduction strategies. Its goal is to **offset warming** while long-term mitigation policies take effect.

Key Findings from Recent Study on SAI

1. **Low-Altitude Injection Feasibility**
   – It is technically possible to inject aerosols at **13 km altitude** using **modified existing aircraft**, making it a **cost-effective and faster option** than designing new high-altitude aircraft.

2. **Quantified Cooling Potential at 13 km**
   – Injecting **12 million tonnes of SO_2 annually** at this altitude could achieve an approximate **global cooling of 0.6°C**.

3. **Increased Aerosol Requirement at Lower Altitudes**
   – To achieve **1°C of cooling at 13 km**, approximately **21 million tonnes of SO_2 per year** would be needed—**three times more** than required at higher altitudes due to shorter aerosol lifespan.

4. **Efficiency of High-Altitude Injection**
   – At **higher altitudes in the subtropics**, only **7.6 million tonnes/year** of SO_2 are needed for the same cooling, as **aerosols persist longer** and spread more efficiently.

5. **Uneven Regional Cooling Effects**
   – Cooling from SAI is **more intense in the polar regions**, while **tropical regions**, despite facing **greater warming**, experience **less benefit** from aerosol injections.

6. **Faster Implementation via Existing Aircraft**
   – Immediate deployment using **current aircraft technology** is possible, whereas developing **custom high-altitude aircraft** could take **a decade or more**.

Global Governance and Policy Perspectives on SAI

1. **2021: US National Academies Recommendation**
   – Recommended **public funding** for research into SAI but emphasized the need for **transparency, public engagement**, and strong **governance frameworks**.

2. **2022: Global Academic Coalition Warning**
   – A coalition of scholars urged for a **moratorium on SAI**, calling it **"ungovernable"**, with concerns about **democratic accountability and public consent**.

3. **IPCC's Cautionary Stance**
   – The Intergovernmental Panel on Climate Change **warns against dependence on SAI**, stressing that it must **not divert attention** from emission reductions and **climate adaptation measures**.

Environmental and Geopolitical Risks of SAI

A. Environmental Risks

1. **Acid Rain Formation**
   – Increased SO_2 in the atmosphere can mix with water to form **sulfuric acid**, leading to **acid rain**, which can **damage ecosystems**, soils, and water bodies.

2. **Ozone Layer Depletion**
   – SO_2-based aerosols can **catalyze ozone-depleting chemical reactions**, potentially **delaying the recovery** of the ozone layer.

3. **Unequal Climate Benefits**
   – The **cooling effect is uneven**, with **tropical regions**—where warming is most acute—benefiting **less** than polar regions, potentially **worsening climate injustice**.

B. Social and Geopolitical Risks

1. **Unilateral Deployment Risk**
   – Without a **global legal or regulatory framework**, a **single country or actor** might implement SAI, risking **global climate disruption** and **sovereignty conflicts**.

2. **Conflict and Global Tensions**
   – SAI could **trigger disputes** between nations over its effects (e.g., altered monsoon patterns or droughts), straining **international relations and multilateral climate frameworks**.

Conclusion and Way Forward

1. **Need for Further Research**
   – Comprehensive, **long-term simulations and impact assessments** are essential before considering deployment of SAI as a climate tool.

2. **Should Not Replace Emission Cuts**
   – SAI must be viewed as a **temporary and supplementary measure**, not as a substitute for **deep emission reductions** or **climate adaptation efforts**.

3. **Global Governance Framework Needed**
   – A robust and **inclusive international regulatory system** is urgently required to **prevent misuse, ensure transparency**, and **avoid geopolitical conflicts**.

Aerosols: Definition and Classification

1. **What Are Aerosols?**
   – Aerosols are **tiny solid particles or liquid droplets** suspended in air or gas. They can be **natural (e.g., sea salt, dust)** or **anthropogenic (e.g., industrial pollution, soot)**.

2. **Climate and Health Relevance**
   – Aerosols influence **Earth's radiation balance**, affect **cloud formation**, reduce **air quality**, and have **direct impacts on human health** through respiratory illnesses.

Types of Aerosols

1. Primary Aerosols

– These are **directly emitted** into the atmosphere from **natural or human sources**.
– **Examples**:
• Sea spray (salt particles from ocean waves)
• Mineral dust from deserts or construction
• Volcanic ash
• Smoke from wildfires or fossil fuel combustion

2. Secondary Aerosols

– These form within the atmosphere via **chemical reactions** involving **precursor gases**.
– **Examples**:
• Sulfate aerosols formed from **SO_2** (from volcanoes or industries)
• Nitrate aerosols formed from **NOx emissions** (from vehicles and power plants)

3. Biological Aerosols (Bioaerosols)

– These consist of **airborne biological particles**.
– **Examples**:
• Viruses (e.g., influenza, COVID-19)
• Bacteria
• Fungal spores
• Pollen grains from plants

Source: https://www.thehindu.com/sci-tech/science/new-study-makes-controversial-weather-tweaking-idea-more-realistic/article69668923.ece