

Pilot Projects Supporting the Feasibility of Sunny Rain Technology: A Practical Platform for Climate Adaptation

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Abstract: This paper presents results from pilot experiments supporting the feasibility of physical mechanisms underlying the Sunny Rain technology, an experimental platform for climate adaptation based on the use of atmospheric water resources. The experiments demonstrate rapid removal of visible smoke under controlled conditions and the collection of airborne desert dust under real-world environmental conditions. These results provide proof-of-principle evidence for mechanisms that may support several proposed applications, including atmospheric water harvesting, air purification, and other climate adaptation measures. The paper further discusses the role of practical adaptation technologies in complementing decarbonization. While decarbonization remains essential for limiting long-term global warming, additional engineering solutions are required to address climate impacts that are already occurring. Sunny Rain is presented as one possible practical platform for this broader adaptation strategy. This leads to a broader technological paradigm in which adaptation and decarbonization are viewed as complementary components of the climate change response.

Key words: Pilot projects, Sunny Rain technology, climate adaptation, atmospheric water, air purification, extreme heat.

1. Introduction

This article presents results from pilot experiments supporting the feasibility of the physical mechanisms underlying the Sunny Rain technology [1], an experimental climate adaptation platform with proposed applications including localized cooling, atmospheric water harvesting, air purification, irrigation, and others. Sunny Rain aims to explore the potential use of atmospheric water resources to address a variety of climate change-related issues.

The article also examines the relationship between adaptation and decarbonization. Decarbonization remains important for addressing a range of issues, including air purification from coal combustion; however, practical adaptation technologies are needed to address existing climate impacts. This leads to a broader technological paradigm in which adaptation and decarbonization are viewed as complementary components of the climate change response [2-7].

This article presents pilot project results supporting

the feasibility of physical mechanisms underlying Sunny Rain technology [1] for addressing key climate change challenges: urban cooling, atmospheric water harvesting, and air purification. Sunny Rain technology provides a broad technological platform capable of supporting climate adaptation strategies while simultaneously addressing multiple challenges.

This article examines the need for decarbonization as an enabling technology, but demonstrates that decarbonization alone is insufficient to address the already inevitable impacts of climate change, leading to a paradigm change in climate change technology: Adaptation and Decarbonization—Our Path [2-7].

2. The “Sunny Rain” Project

2.1 “Sunny Rain” Is an Experimental Climate Change Adaptation Project Designed to Address Increasingly Important Global Challenges, Including

- mitigating the effects of extreme heat;
- harvesting water from the cloudless atmosphere;

- irrigation, with the potential to increase crop yields;
- improving air quality;
- absorbing greenhouse gases and pollution;
- extinguishing fires and addressing other issues.

Sunny Rain is a new platform for climate change adaptation using atmospheric water resources.

2.2. Atmospheric Water Resources

The atmosphere contains approximately 12,900 km³ of water vapor, compared to approximately 2,100 km³ stored in the world's rivers and a significantly smaller amount in thunderclouds. The "Sunny Rain" project aims to explore ways to use some of this vast atmospheric water resource to improve water and food security worldwide. Water and food security are increasingly recognized as central components of climate resilience in many vulnerable regions of the world.

2.2.1 Creation of an Additional Renewable Source of Irrigation Water

The Sunny Rain system is designed to create an additional renewable source of irrigation water by utilizing the vast store of atmospheric water vapor contained in cloudless air (see Section 2.2).

2.2.2 Integrated Use of Atmospheric Carbon Dioxide

Unlike traditional irrigation systems, the Sunny Rain system is designed to simultaneously utilize atmospheric CO₂ dissolved in irrigation water as an additional factor that can contribute to increased agricultural productivity and simultaneously facilitate adaptation to climate change.

2.2.3 The Effects of Extreme Heat

An atmospheric water source can be used to achieve a controlled reduction in air temperature through two physical mechanisms.

1. The evaporation of rainwater leads to a rapid decrease in air temperature.
2. A potential reduction in the mass of greenhouse gases in the air over the cooled area could contribute to a decrease in air temperature.

3. The objective is not simply to reduce greenhouse gas emissions over decades, but to achieve a rapid reduction in local air temperature—an effect that decarbonization alone cannot provide—in areas where extreme heat already threatens human health, agriculture, and infrastructure (which decarbonization alone cannot achieve).

2.3.4 Reduction of Air Humidity

A potential decrease in air humidity during the Sunny Rain process may result from the ability of Sunny Rain condensation nuclei to capture water vapor from the atmosphere.

2.3.5 Combined Effects of Temperature and Humidity

A cloud precipitation is accompanied by increased humidity. The combination of high air temperature and high relative humidity can have a particularly adverse impact on thermal comfort and human health. Therefore, to characterize the combined effects of air temperature (t_c C) and relative humidity ($\chi(\%)$) in hot weather, the US NWS (National Weather Service) uses the Rothfusch regression to calculate the heat index (t_c C) (see Table 1).

Summary:

1. Table 2 illustrates the importance of simultaneously reducing both air temperature and relative humidity. The Sunny Rain concept is designed to address both factors.

2. Singapore provides an important example of a tropical environment characterized by persistently high temperatures and humidity. As extreme heat intensifies, the combined effects of temperature and humidity may increasingly threaten human health and thermal safety.

Table 1 Heat index (t_c C).

	$\chi(\%)$	60	80	90
t_c C = 30	$t_c =$	34	38	41
t_c C = 35	$t_c =$	46	57	64
t_c C = 40	$t_c =$	60	83	95

3. Briefly about the Results of the Pilot Projects Completed

3.1 The Sunny Rain Initiative Is Intended to Address the Following Challenges

1. Harvesting water and capturing greenhouse gases from cloudless air, including in arid and desert regions (e.g., the Arava and Negev).
2. Reducing urban air temperatures and mitigating the effects of extreme heat.
3. Providing additional irrigation water and increasing agricultural productivity.
4. Removing pollutants from the air in urban and industrial areas.
5. Improving environmental conditions that affect human health and well-being.
6. Dissipating fog at airports.
7. Supplementing water resources in shallow rivers and Lake Kinneret.
8. Irrigating green areas on slopes and in urban environments.
9. Supporting the suppression of fires.
10. Reducing smoke density to assist firefighters in rescuing people trapped during fires.
11. Removing airborne desert dust and other pollutants.

3.2 Pilot Project #1: Removal of Smoke and Water Vapor Using Sunny Rain

An airtight container was filled with dense smoke produced by waste incineration (Fig. 1). Sunny Rain condensation nuclei were then introduced into the smoke-filled container. Within approximately 10 seconds, the visible smoke had dissipated, while condensed water accumulated on the inner walls of the container (Fig. 2).

The main conclusions are:

1. The predicted ability of Sunny Rain nuclei to capture airborne smoke pollutants was experimentally confirmed (see Problems 1, 10) An atmospheric water source can be used to achieve a controlled reduction in

air temperature through two physical mechanisms.

2. The high practical effectiveness of Sunny Rain nuclei was successfully demonstrated within a few seconds. The value of experiment #1 also lies in the fact that the quantitative characteristic-time of smoke capture is measured, which will allow in the future simply grading the created condensation nuclei to solve different problems.

3. The experiment confirms the feasibility of using Sunny Rain to solve not only Problem 1, 10, but also related Problems 4 and 6 (just different pollutants), and emphasizes its potential to solve Problems 1, 2, 3, 5, 7, 8, 9, 11.



Fig. 1 Airtight container filled with dense smoke produced by waste incineration before the introduction of Sunny Rain condensation nuclei.



Fig. 2 Approximately 10 seconds after the introduction of Sunny Rain condensation nuclei: the visible smoke had dissipated and condensed water had accumulated on the inner walls of the container.



Fig. 3 The experimental collection of airborne pollutants was successful.

This experiment establishes proof of principle for the underlying physical mechanism on which multiple proposed applications are based.

3.3 Pilot Project #2: Removal of Airborne Desert Dust Using Sunny Rain

Sunny Rain condensation nuclei were released from the eighth floor into the stairwell of a residential building during conditions of wind-blown desert dust (Fig. 3). A film was placed on the floor to collect water and airborne material captured during the experiment. The collected liquid contained visible particulate matter. After the water had evaporated, the remaining sediment was photographed (Fig. 3).

The main conclusions are:

1. The experimental collection of airborne pollutants was successful.
2. The theoretical ability of Sunny Rain cores to capture airborne pollutants (Problem 11) was confirmed experimentally.
3. Successful collection was demonstrated even from a relatively low release altitude of approximately 25 meters.

4. A Changing Paradigm in Climate Change Technology

4.1 Current Decarbonization-Based Climate Strategy and Its Limitations

1. The dominant global response to climate change has focused primarily on mitigation through decarbonization.

António Guterres has emphasized that limiting global warming to 1.5 °C requires a transition away from fossil fuels and accelerated decarbonization [2].

2. Limitations of current climate action:

The limitations of current climate action are also reflected in recent UNEP (United Nations Environment Programme) assessments and initiatives:

- In 2024, UNEP emphasized that current climate policies remain insufficient to achieve internationally agreed climate goals. As part of the GEO-7 process, UNEP also invited experts to contribute to the assessment of solutions addressing the triple planetary crisis [3-7].

- Recent statements by the United Nations and UNEP emphasize both the inadequacy of current measures and the growing importance of practical climate adaptation [3-6].

3. UNEP Executive Director Inger Andersen's official statement for the *2024 Climate Adaptation Gap Report* states:

In her statement accompanying UNEP's *Emissions Gap Report 2024*, Executive Director Inger Andersen emphasized the inadequacy of current climate policies:

- "Worse, current policies are insufficient even to meet these NDCs (Nationally Determined Contributions). If nothing changes, we are headed for a 3.1 °C temperature increase" [3].

Current NDCs point to a global temperature increase of approximately 2.6-2.8 °C over this century [3].

4.2 Toward an Integrated Climate Strategy: Decarbonization and Adaptation

The worsening impacts of climate change have increased recognition that mitigation through decarbonization must be complemented by adaptation measures addressing climate impacts that are already occurring.

António Guterres states: "Decarbonization of economies and adaptation are the path to saving humanity" [7].

1. The growing importance of adaptation:

António Guterres has emphasized the need to adapt to climate impacts that are already occurring. He noted that only about 20% of climate finance was being allocated to adaptation and stressed that investments in

climate resilience can both save lives and generate substantial economic benefits. According to the UN Secretary-General, every dollar invested in adaptation measures can generate almost four dollars in benefits [6]. He also warned that without adequate adaptation measures, many small island developing states face existential risks.

2. UNEP Executive Director Inger Andersen's official statement for the *2024 Climate Adaptation Gap Report* states:

In her statement accompanying UNEP's *Adaptation Gap Report 2024*, Executive Director Inger Andersen emphasized the urgency of adaptation:

"There is simply no excuse for the world not taking adaptation seriously" [6].

Taken together, these statements indicate growing international recognition that mitigation must be complemented by practical adaptation measures and technologies.

3. Sunny Rain is presented as one possible practical adaptation platform illustrating how climate adaptation can move from policy objectives to engineering implementation.

5. Conclusion

1. The pilot experiments provide proof-of-principle evidence supporting the feasibility of the underlying physical mechanisms of Sunny Rain. The results demonstrate the potential of these mechanisms for several proposed climate adaptation applications.

2. Decarbonization remains essential for limiting long-term global warming, but it is not designed to provide rapid, localized reductions in air temperature during extreme-heat events. Practical adaptation technologies are therefore also needed to address climate impacts that are already occurring.

3. A well-known adaptation technology for reducing urban heat involves spraying water on streets and rooftops, using evaporation to cool buildings and the air.

- Since Sunny Rain technology uses the atmosphere itself as a water source, it has significantly greater

potential than local adaptation systems. Furthermore, the significantly lower cost of water from Sunny Rain must be taken into account.

4. As climate impacts intensify, practical adaptation should become an increasingly important pillar of the global climate response alongside continued decarbonization. Sunny Rain represents one proposed technological platform for translating this adaptation objective into practical engineering applications.

5. Therefore, the emerging paradigm should be understood as a transition from decarbonization to a more integrated strategy combining decarbonization with practical adaptation technologies capable of addressing the adverse effects of climate change.

6. The proposed paradigm is technology-neutral and is intended to encourage the development and evaluation of multiple practical adaptation solutions, with Sunny Rain representing one possible example.

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