CASE STUDY | CLIMATE IMPACT ON CLOUD SEEDING

THE SHRINKING WINDOW FOR CLOUD SEEDING

Why Climate Warming Narrows AgI Seeding and Expands the Case for Ionization Technology

Based on peer-reviewed research by Dr. Binod Pokharel et al., published in Atmospheric Research (Elsevier, 2021)*

A peer-reviewed study published in Atmospheric Research in 2021 provides an examination of how climate warming will affect a state's cloud seeding conditions. The findings carry major implications for water resource managers who depend on traditional silver iodide (AgI) seeding to augment snowpack in the western United States.

Using 13 years of high-resolution climate model data from the National Center for Atmospheric Research (NCAR), lead author Dr. Binod Pokharel and his team evaluated how rising temperatures under a high-emissions warming scenario would alter the viability of wintertime cloud seeding across Utah's mountain ranges.

Their conclusion: climate warming will substantially narrow the operational window for AgI-based cloud seeding.

The Temperature Problem

AgI seeding is effective within a specific range of cloud temperatures, typically between −6°C and −20°C. This temperature is evaluated either at the 700 mb level or, alternately, as an average from the surface to 1 km above ground level. Under the warming scenario studied, temperatures across Utah's mountains increase by roughly 4 degrees C. The frequency of suitable seeding temperatures drops by more than 24% across most mountain terrain. The fraction of precipitating storms suitable for seeding falls from about 60% to about 40% statewide, a roughly one-third decline. Meanwhile, the study shows that supercooled liquid water availability actually increases under warming, providing more moisture for technologies that don't depend on the AgI temperature band.

	AgI Cloud Seeding	WETA Ionization
Temperature window	**-6 to -20 deg. C only** Shrinks 24% with warming	**No thermal restriction** Works warm and cold
Cloud types supported	**Stratiform only** Ice nucleation pathway	**Stratiform + mixed-phase** Coalescence of SLW+ice
Seasonal availability	**Nov - Mar only** Misses warm-season rain	**Year-round** Captures all precipitation
Climate resilience	**-33% fewer storms** Shrinks as temps rise	**Window may expand** More SLW under warming
Chemical input	**Silver iodide dispersal** Minimal chemical agents	**No chemical agents** Ion generation only
	Less effective	More effective

RAIN ENHANCEMENT TECHNOLOGIES

MORE RAIN. MORE SNOW. GUARANTEED.

~33%

Decline in Seedable Storm Fraction

Under high-emissions warming scenario

60% > 40%

Precipitating Storms Suitable for AgI Seeding

Statewide decline across Utah's mountains

4°C

Avg. Temperature Increase in Utah

Narrowing the thermal window for AgI activation

>20%

SWE Enhancement by WETA at La Sal

During driest winter on record, 2025-26

Learn more at

rainenhancement.com

Proven Results

The La Sal Mountains Connection

The Pokharel study specifically identifies the La Sal and Abajo Mountains as "isolated mountains" with favorable seeding conditions only about 10 to 15% of the time during winter. By contrast, RAIN's WETA system was operational 33% of the time in these same mountains during winter 2025-2026, one of the driest winters on record.

Despite conditions that the peer-reviewed literature characterizes as having limited suitability for traditional cloud seeding, RAIN's WETA system delivered greater than 20% SWE (Snow-Water Equivalent) enhancement at the La Sal Mountains. Three independent statistical methods (analog years, ridge regression counterfactual modeling, and Bayesian Structural Time Series analysis) all converge on this result with seasonal confidence exceeding 80%.

More Precipitation, Fewer Storms = Higher Value Per Event

The study projects that total winter precipitation may actually increase under warming, but the frequency of precipitation events will decrease. Each storm becomes more valuable from a water capture perspective. Traditional cloud seeding programs face fewer eligible storms, and those storms may increasingly be convective and harder to seed effectively. WETA's ability to operate continuously and autonomously, activating within hours, positions it to capture value from every precipitation event rather than waiting for conditions that meet narrow AgI criteria.

Year-Round Operations

The study only analyzes the November-through-March winter season because that is the only window where AgI seeding is viable. WETA operates year-round, including warm-season precipitation events. The study's warming scenario suggests that more precipitation may shift to convective, warm-season patterns, which fall entirely outside the scope of traditional winter cloud seeding programs but remain within WETA's operational envelope.

ABOUT THE AUTHOR

Binod Pokharel, PhD

Dr. Pokharel is a Research Faculty at Utah State University and an Associate Professor at Tribhuvan University, Nepal. He holds a PhD and MS in Atmospheric Science from the University of Wyoming, with over 25 years of experience in meteorology and climate research.

A specialist in cloud seeding, aerosol, and precipitation processes, Dr. Pokharel has led multiple winter orographic cloud seeding projects in Utah and contributed to field campaigns in Wyoming and India.

He established cloud seeding research programs in Utah and has published numerous peer-reviewed papers on the impacts of glaciogenic seeding. He is the first recipient of the North American Weather Modification Council (NAWMC) Scholarship.

THE RAIN CONNECTION

Peer-reviewed science confirms that traditional cloud seeding faces a declining operational window as the climate warms. RAIN's ionization technology was designed to overcome exactly these limitations. The very mountains this research identified as having limited AgI suitability became the proving ground for WETA, where the system delivered greater than 20% SWE enhancement during the driest winter on record. As warming continues to narrow the window for traditional seeding, WETA's operational envelope holds steady or expands.

*Source: Pokharel, B., Wang, S.-Y.S., Gu, H., LaPlante, M.D., Serago, J., Gillies, R., Meyer, J., Beall, S., & Ikeda, K. (2021). A modeling examination of cloud seeding conditions under the warmer climate in Utah, USA. Atmospheric Research, 248, 105239. https://doi.org/10.1016/j.atmosres.2020.105239

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Ready to Future-Proof Your Precipitation Enhancement Program?
RAIN's WETA system delivers proven results today and is designed to perform even better as the climate warms, operating where traditional cloud seeding cannot.