

50 YEARS OF THAILAND CLOUD SEEDING ACTIVITY

Warawut Khantiyanan *
Bureau of the Royal Rainmaking and Agricultural Aviation, Bangkok, Thailand

1. INTRODUCTION

Climate is particularly critical to Thailand because surface water is the prevalent source of water used. Hence, rainfall is critical in terms of both timing and distribution. Thailand has a progressive agricultural system and the growing need for water appears most heavily related to the needs of an expanding population and Thai economy, which need more water to meet its expanding agricultural and energy demands. Besides, drought condition occurs more frequently and tends to be more severe than before, possibly resulting from unsolved development problems such as deforestation, changing of land uses, and increasing of atmospheric pollution.

Recognizing the potential in augmenting national water supplies, a concept of rainmaking or rain enhancement by means of cloud seeding was introduced by His Majesty King Bhumibol Adulyadej of Thailand on 14 November 1955. Since the late 1960's scientific and technical organizations in the Kingdom of Thailand have been involved with a series of experiments and operational programs to increase rainfall through weather modification. A national scale program of weather modification began in 1971 and was formalized in 1975 through establishment of the Bureau of Royal Rainmaking and Agricultural Aviation (BRRAA).

Rainmaking operation in Thailand is now playing an important role as one tool in management of the national water resources in line with the increase of water demand of the country.

2. PRESENT STATUS

2.1 Organization

BRRAA has a staff of over 500 persons including scientists, engineers, pilots, aircraft and electronic technicians, general administrators, and labors. The BRRAA also has its own sizable facilities and extensive equipment such as cloud seeding aircraft (21 units), cloud-physics aircraft (2 units), Doppler weather radar (5 units), and rawinsonde (5 units). The BRRAA Head Quarter is in Bangkok and its field activities run by the rainmaking operation center (8 units) and the rainmaking research centers (4 units) (see fig.1). The annual funding level is about \$US 20 million.

*Corresponding author address: Warawut Khantiyanan, BRRAA, Ministry of Agriculture and Cooperatives, Bangkok 10900, Thailand, E-mail: warawutku@yahoo.com

2.2 Activities

2.2.1 Operational Mission

The principal objective of the operational mission is to increase rainfall through the seeding of clouds over the important water basins and agricultural areas of Thailand, where rainfall in some years is less than optimal for crop production. The cloud seeding program is based on a seeding technique that is unique to Thailand: the seeding of warm clouds and cold clouds in a four-step process with exothermic, endothermic, Silver Iodide, and Dry-ice chemicals delivered in a specified time and space sequence in an attempt to produce a combination of dynamic and microphysical effects. The annual field operation missions normally start from the beginning of summer (February) to the end of rainy season (October).

2.2.2 Research Mission

The principal objective of the mission is to develop a scientifically-based rainmaking capability with a quantified water augmentation potential which should be complemented by a quantitative assessment of the utility and value of the additional water in economic and environmental terms. Besides, there are still more questions than there are answers as to how cloud seeding works in Thai clouds. The research to answer more of these questions continues.

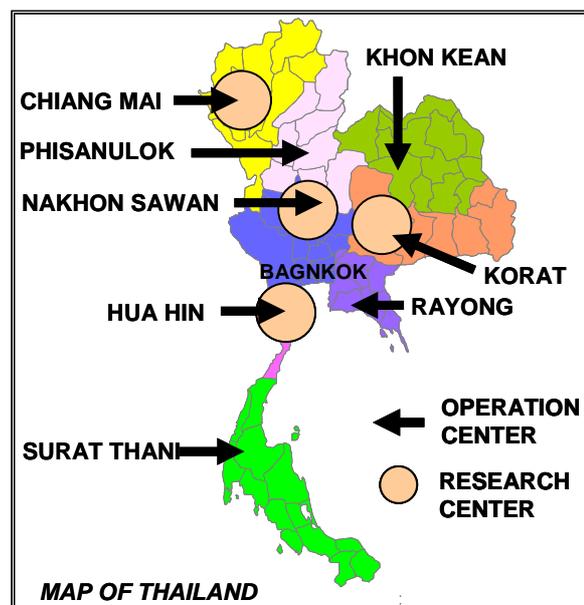


Figure 1 – The location of operation & research centers

3. SCIENTIFIC RESULTS

3.1 Results of the 5-Year Experimental Program

One of the research efforts under the BRRAA is known as the Applied Atmospheric Resources Research Program (AARRP). The Program involved the conduct and evaluation of the randomized warm-cloud and cold-cloud seeding experiments in the Bhumipol catchments area in northwestern Thailand.

3.1.1 Warm Cloud Seeding Results

A warm cloud seeding experiment under AARRP was carried out during 1995-1998. The experiment was designed to test whether the seeding of warm, tropical convective clouds with calcium chloride particles can produce statistically significant increases in rainfall. The experiment was conducted in accordance with a randomized floating single target design (Silverman, et al., 1994).

Table 1 gives the results of the evaluation of these secondary response variables. It can be seen that the statistically significant increase in the lifetime property rain volume (RVOLMAX) is accompanied by a statistically significant increase in area (AMAX), a strongly suggested increase in rain volume rate (RVRMAX) that was not statistically significant, and a strongly suggested decrease in peak reflectivity (ZMAX) that was not statistically significant. No significant changes in echo-top height (HMAX), number of cells (NCMAX), and rain duration (DUR) are indicated (Silverman, et al., 2000).

Table 1. Evaluation of the warm-cloud experiment. Values of SR-1 (the proportional effect of seeding) with P values ≤ 0.10 are shown in boldface; those with P values ≤ 0.05 are italicized.

Variable	Avg S	Avg NS	SR-1	P Value
RVRMAX ($\times 10^3 \text{ m}^3 \text{ h}^{-1}$)	315.76	196.47	0.61	0.07
HMAX (km)	7.68	7.65	0.00	0.47
ZMAX (dBZ)	38.98	43.93	-0.11	0.08
DUR (min)	152.71	136.85	0.12	0.29
AMAX (km^2)	49.13	29.92	0.64	0.03
NCMAX	2.20	2.53	-0.13	0.23

3.1.2 Cold Cloud Seeding

A randomized cold-cloud seeding experiment was carried out during portions of April, May and June in 1994-1998. The physical-statistical design was aimed at determining whether seeding with ejectable, free-fall, silver iodide flakes near the tops (temperatures -6°C to -10°C) of vigorous supercooled convective clouds growing within a floating-target area would enhance the rainfall over that area (Silverman, et al., 1994).

Table 2 gives the results of the evaluation of the cold cloud seeding experiment. The proportional effects of seeding on cell RVOL and unit rainfalls

RVOL at 300 min after unit are 35% with a one-sided P value of 0.139 and 46% with a one-sided P value of 0.107, respectively, which fall short of the P -value threshold 0.025 that is required for statistical significance. It can be seen that the Thai cold-cloud demonstration experiment did not reach statistical significance in the time allotted to it. Thus, this experiment did not "demonstrate" or prove the efficacy of glaciogenic cloud seeding in this context. (Woodley, et al., 2002).

Table 2. Results of cell and unit analyses for the demonstration experiment (RVOL in kilotons or 10^3 m^3). RVOL S and RVOL NS are the rain volumes from cells or units that were seeded and not seeded, respectively.

Variable	RVOL S	RVOL NS	SR-1	P Value
Cells	361.52	267.31	35	0.139
Units (300 min)	7810.95	5333.85	46	0.107

3.2 Results of the real operation mission in 2006

Cloud seeding operation mission in 2006 was started from February through October and ran by 8 rainmaking operation teams throughout Thailand. The overall results show highly successful under 3 Key Performance Indices (KPI). They are as follows:

- (1) The number of rainfall days in the designated target area was 96% of the number of seeded days.
- (2) The total benefit area from cloud seeding was 98 million acres.
- (3) All of the dams in the responsible area reached the water storage of more than 80% of their maximum storage capacities.

4. CONCLUSION

At present, rain enhancement is proven to be successful and applied widely in Thailand. It provides considerable benefits to the nation's natural resources and economy. It becomes one of several ways to solve the water problems and benefits from its use are maximized as an integral part of a multi-solution approach to water resources management.

5. REFERENCE

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