

Royal Rainmaking

and

**ASEAN Weather
Modification Activities**

Background



1955 : The rainmaking concept was initiated by H.M. the King.

H.M. had appointed the late M.R.Teparit Devakul, a famous Agri. Engineer and inventor to study the problem.



1969 : The first rainmaking experiment in the sky was conducted.

The result observed was quite promising and encouraging.

1971 : The first rainmaking operation was conducted upon the request of paddy growing farmer.

From 1971 on, the requests for RM services increased yearly.





Then, the research and experiment have been carried on in parallel with the operation until today



1973 : H.M. has concluded the first royal rainmaking technology, used for warm rain modification process

The research stage of the basic royal rainmaking technology was considered to be accomplished.

But the development of supplementary technics has been conducted and carried on respectively up to now



1975 : The Royal Rainmaking R&D Institute (RRRDI) was established, attached to the Office of Permanent Secretary, Ministry of Agriculture and Cooperatives.

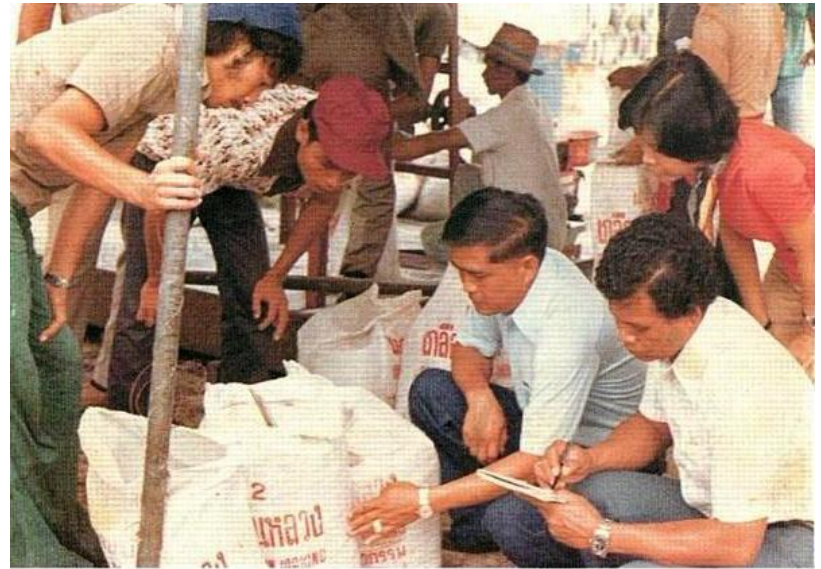
The principal objective has been to increase rainfall through the seeding of clouds over the important agricultural areas of Thailand, where rainfall in some years is less than optimal for crop production

1992 : RRRDI was re-organized and upgraded to Bureau of Royal Rainmaking and Agricultural Aviation (BRRAA).



2013 : BRRAA was re-organized and upgraded to Department of Royal Rainmaking and Agricultural Aviation (DRRAA).

1976 : Indonesian Team visited Thailand to seek possibilities for implementing weather modification technology in Indonesia.



1977 : Cloud seeding as a Project Research was conducted in Bogor and Sukabumi (West Java Province), and Solo (Central Java Province) as a collaboration with The Royal Rainmaking Thailand.



Indonesia 2519(1976), 2520(1977), 2521(1978), 2524(1981), 2525(1982)

1985 : Cloud Seeding Project Research became Weather Modification Technology Center (WMTC) Under Agency for the Assessment and Application of Technology (BPPT).

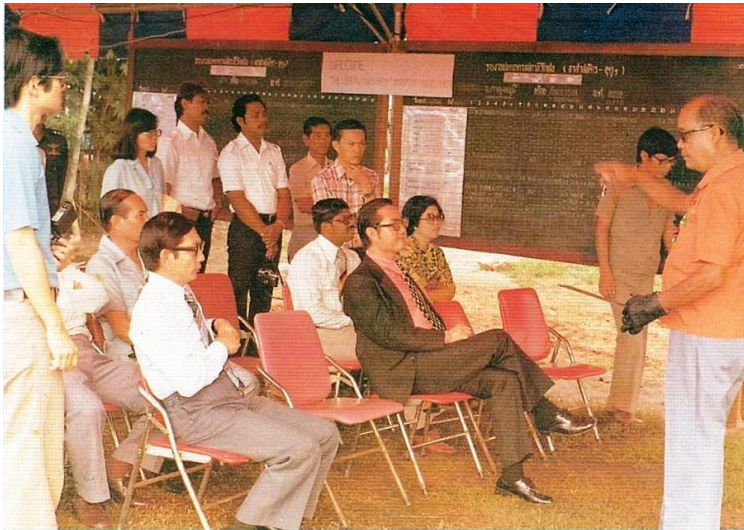
The mission of the WMTC is to provide services on rain enhancement in order to obtain more water over any catchment area, to extinguish forest/field fires, and to clear up smoke for both government and public sectors in Indonesia.

In 1977, Malaysia experienced a severe drought and the subsequent water shortage forced the farmers in the MADA region (the rice bowl of Malaysia) to abandon the crop completely.

The government then requested the Malaysian Meteorological Service (MMS) to carry out cloud seeding operation to increase the water stored in the Pedu and Muda dams so as to provide sufficient water for off-season crops.

MMS sent a team to visit RRRDI.

1979 : Minister of Transport and DG MMS visited RRRDI.
Prof. Devakul directed Rainmaking Operation for
Sri Nakaran Dam



In 1979, at the request of the National Electricity Board, MMS started to carry out cloud seeding operation over the Temengor catchment areas.



6-26 December 1979 Rainmaking Experiment at the Temengor Hydroelectric Dam

ASEAN SCC – ASEAN Sub-committee on Climatology
ASEAN SCMG – ASEAN Sub-committee on Meteorology and Geophysics

1979 : MMS invited RRRDI to attend ASEAN SCC

1981 : Chairman of ASEAN Weather Modification Working Group



1982 : Royal Rainmaking Technology and activities registered in weather modification program, WMO

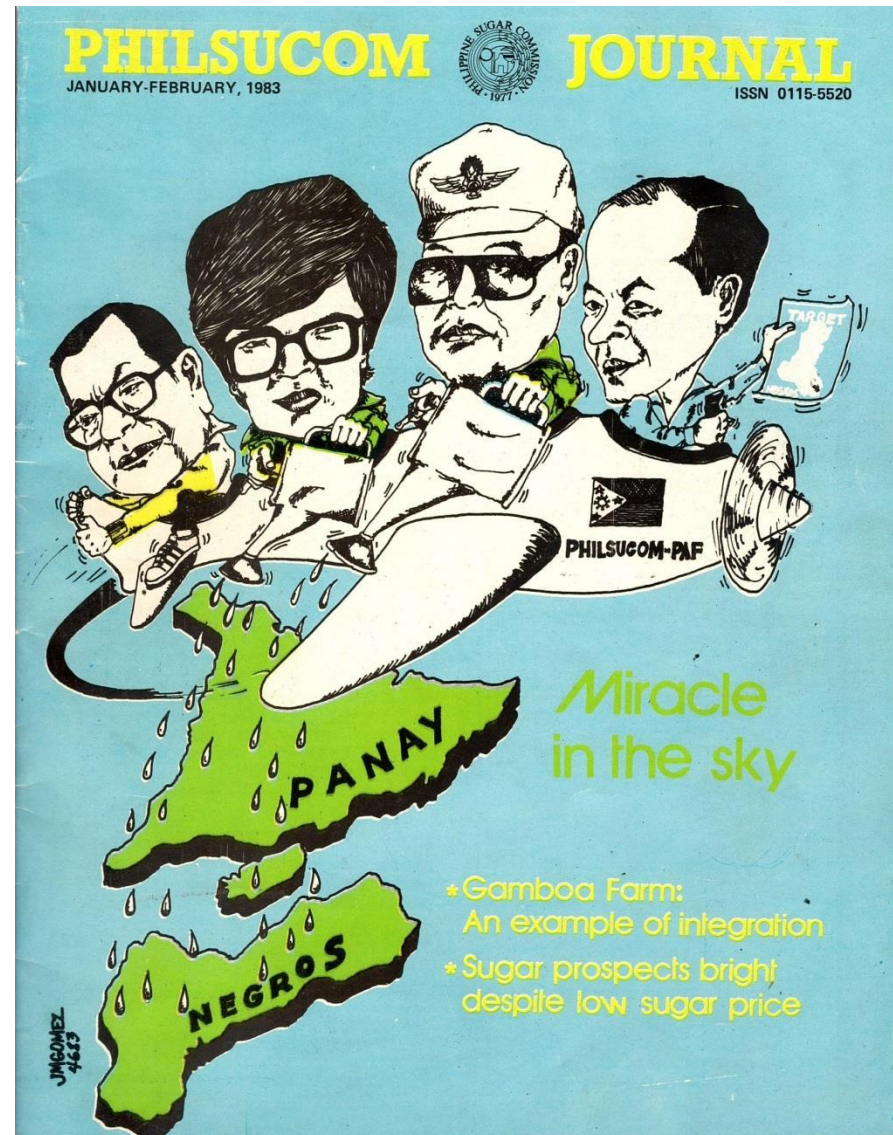


**World
Meteorological
Organization**

Weather • Climate • Water

1983 : Due to severe drought which has occurred over the several months on Negros and Panay Islands causing great damage to sugarcane and rice.

Philippine Sugar Commission (PHILSUCOM) invited RRRDI Rainmaking Team to come to Negros using Bacolod Airport to urgent ease the drought.





1984 : The First ASEAN Seminar on Weather Modification and Evaluation Techniques, WMO & UNDP & COST





DR. L. R. KOENIG

ผู้แทนจากองค์การอนามัยโลก (wmo)



DR. W. A. COOPER



DR. JOHN FLUECK



PROF. R. LIST



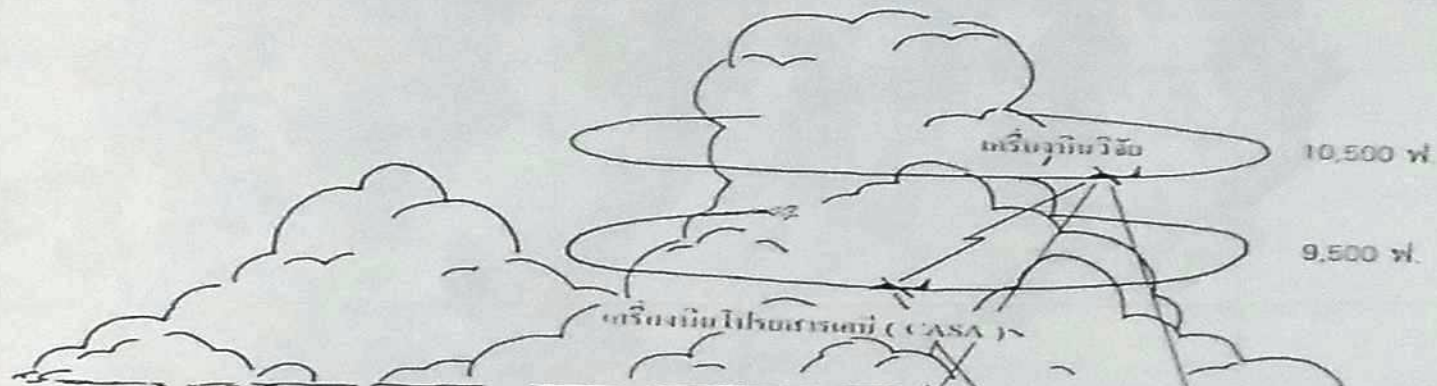
PROF. TSUTOMU TAKAHASHI

1988 : The Applied Atmospheric Resources Research Program (AARRP) was launched as a joint project of the RTG (BRRAA) and the U.S. Government (USAID).

The project was conducted in 1991 – 1998.







10,500 ฟ.
9,500 ฟ.

เมฆชั้นอัลโต

เมฆชั้นนิโบลอสตราอิม (CASA)

สายโทรศัพท์ส่งข่าวสารและข้อมูล

สถานีเรดาร์ฝนหลวง

ศูนย์วิจัยปฏิบัติการฝนหลวง

เขื่อนภูมิพล

สายโทรศัพท์ส่งข่าวสารและข้อมูล

1988 : The Consultation on Weather Modification Activities in ASEAN countries, MAOC & TMD & WMO



1994 : ASEAN Workshop on a Scientific Plan for ASEAN Cooperative Weather Modification Project



MEMORANDUM ON THE PROPOSED ASEAN COOPERATIVE WEATHER MODIFICATION PROJECT

ON THE DAY OF MARCH 4, 1994 AT THE ASEAN WORKSHOP ON "SCIENTIFIC PLAN FOR AN ASEAN COOPERATIVE WEATHER MODIFICATION PROJECT" DUSIT RESORT AND POLO CLUB HOTEL, CHA-AM, PHETCHABURI, THAILAND, IT IS AGREED UPON BY THE REPRESENTATIVES FROM THAILAND, MALAYSIA, AND PHILIPPINES AS FOLLOWS:

1. THAILAND WILL BE A CENTER FOR THE WEATHER MODIFICATION TO CARRY OUT THE FOLLOWING FUNCTIONS:

1.1 A VENUE FOR ALL ASEAN MEMBER COUNTRIES TO PULL TOGETHER ALL THEIR RESOURCES, INSTRUMENTS AND MAN POWER TO OPERATE JOINT EXPERIMENTS, RESEARCHES, AND TRAINING IN CLOUD SEEDING AND VARIOUS OTHER WEATHER MODIFICATION PROJECTS.

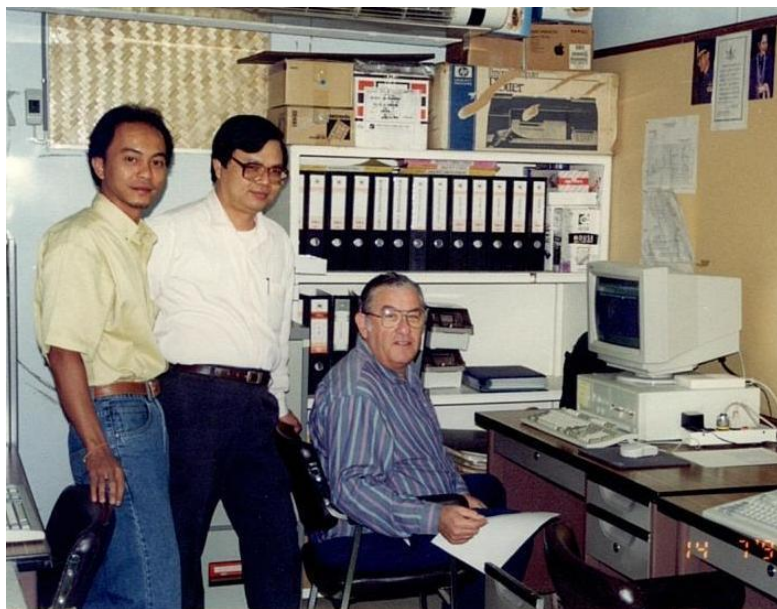
1.2 A VENUE FOR WEATHER MODIFICATION DATA BASE WHICH SCIENTIFIC INFORMATION CAN BE EXCHANGED AND SHARED AMONG ASEAN MEMBER COUNTRIES.

2. THE ESTABLISHED CENTER WILL COORDINATE THE PARTICIPATION OF THE SCIENTISTS AND/OR PERSONNEL OF THE MEMBER COUNTRIES IN THE AARRP PHASE II AND OTHER WEATHER MODIFICATION PROJECTS OF MUTUAL INTEREST TO THE PARTICIPATING MEMBERS.

3. THE CENTER WILL COLLABORATE AND SEEK TECHNICAL AS WELL AS FINANCIAL ASSISTANCE'S FROM THE GOVERNMENTAL AND NON-GOVERNMENTAL ORGANIZATIONS IN THE ASEAN MEMBER COUNTRIES AND INTERNATIONAL ORGANIZATIONS TO FINANCE THE CONDUCT OF ACTIVITIES UNDER THE ASEAN COOPERATIVE WEATHER MODIFICATION PROJECT; THE SCOPE WILL INCLUDE COUNTRIES OUTSIDE THE REGION SUBJECTED TO THE APPROVAL OF ASEAN SCMG.

3-5 April 1995 Dr. Modesto L. Borja,
Chief of the National Artificial Rain
Stimulation Office (NARSO),
Bureau of Soils and Water Management
visited Northern Rainmaking Center and
Omkoï Radar Station

1996 : Two Scientists from WMTC joined AARRP for two months
(15 May - 15 July)
Ir Dwipa Wirawan Soehoed, Ir Erwin Mulyana



1 June - 31 July 1997 : Two Scientists from WMTC joined
AARRP for two months

Drs Sunu Tikno Head of Hydrology and
Environment Group

Drs Rino B. Yahya Member of Technical
Design Group

5-13 October 1997 Mrs. Eugenia A. Briones,
Chief of Air Operation Section, NARSO
Bureau of Soils and Water Management
visited Eastern Rainmaking Center and
Omkoï Radar Station



Assessment of the effects of smoke
on Indonesian clouds project.
12-22 December 1997

The cooperative program of cloud physics measurements was conducted in potential rain cloud over Indonesia in the context of drought and fire that afflicted the region.

BRRAA, Thailand
WMTC, Indonesia
NCAR, USA

Assessment of the effects of smoke
on Indonesian clouds project.

12-22 December 1997

Objectives :

To determine the effect of the smoke from the fire on the precipitation efficiency of the cloud

To determine which, if any, method of cloud seeding might be used to mitigate the deleterious effects of the drought.

1999 : 7th WMO
Scientific Conference on
Weather Modification,
WMO & RTG

WORLD METEOROLOGICAL ORGANIZATION

PROGRAMME ON PHYSICS AND CHEMISTRY OF
CLOUDS AND WEATHER MODIFICATION RESEARCH

WMP
REPORT No. 31

SEVENTH WMO SCIENTIFIC CONFERENCE
ON WEATHER MODIFICATION

Technical
Document

Chiang Mai, Thailand

(17-22 February 1999)

Volume I



WMO/TD - No. 936

ตัวแปร	หน่วย	การทดลองทำฝนจากเมฆอ่อน (ปี 1995 - 1998)		
		ค่าเฉลี่ยหน่วยทดลอง	ค่าเฉลี่ยหน่วยทดลอง	อัตราส่วน
		ที่ใช้สารเคมี (Seed, S)	ที่ไม่ใช้สารเคมี (No Seed, NS)	S/NS-1
ปริมาณน้ำฝน (RVOL)	m ³	137.1 X 10 ³	65.61 X 10 ³	1.09
อัตราปริมาณน้ำฝน (RVRMAX)	X 10 ³ m ³ h ⁻¹	315.76	196.47	0.61
พื้นที่ฝนตก (AMAX)	km ²	49.13	29.92	0.64
ระยะเวลาการตกของฝน (DUR)	min	152.71	136.85	0.12
ความสูงของยอดเมฆ (HMAX)	km	7.68	7.65	0.00
ความเข้มของการตรวจวัด (ZMAX)	dBZ	38.96	43.93	-0.11
จำนวนกลุ่มเมฆที่เกิดขึ้น (NCMAX)		2.20	2.53	-0.13

ตัวแปร	หน่วย	การทดลองทำฝนจากเมฆเย็น (ปี 1991 - 1998)		
		ค่าเฉลี่ยหน่วยทดลอง	ค่าเฉลี่ยหน่วยทดลอง	อัตราส่วน
		ที่ใช้สารเคมี (Seed, S)	ที่ไม่ใช้สารเคมี (No Seed, NS)	S/NS-1
ปริมาณน้ำฝน (RVOL)	m ³	7.79 X 10 ⁶	5.26 X 10 ⁶	0.48
อัตราปริมาณน้ำฝน (RVRMAX)	X 10 ³ m ³ h ⁻¹	780.25	538.10	0.45
พื้นที่ฝนตก (AMAX)	km ²	375.69	321.10	0.17
ระยะเวลาการตกของฝน (DUR)	min	175.80	167.43	0.05
ความสูงของยอดเมฆ (HMAX)	km	9.99	10.30	-0.03
ความเข้มของการตรวจวัด (ZMAX)	dBZ	41.80	45.90	-0.09
จำนวนกลุ่มเมฆที่เกิดขึ้น (NCMAX)		22.00	17.60	0.25



Royal Rainmaking Mission and Operation for Solving Drought and Natural Disaster in Thailand

Department of Royal Rainmaking and Agricultural Aviation (DRRAA)



Rainmaking organization



1975

**Royal Rainmaking R&D
Institute**

1993

**Bureau of Royal Rainmaking
and Agricultural Aviation**



2013

**Department of
Royal Rainmaking and
Agricultural Aviation
under Ministry of
Agriculture and Cooperatives**



Royal Rainmaking

Department of Royal Rainmaking and Agricultural Aviation (DRRAA)

Vision



In 2036, DRRAA will be the world leading organization of weather modification in accordance with technique developed by **His Majesty King Bhumibol Adulyadej**

Mission

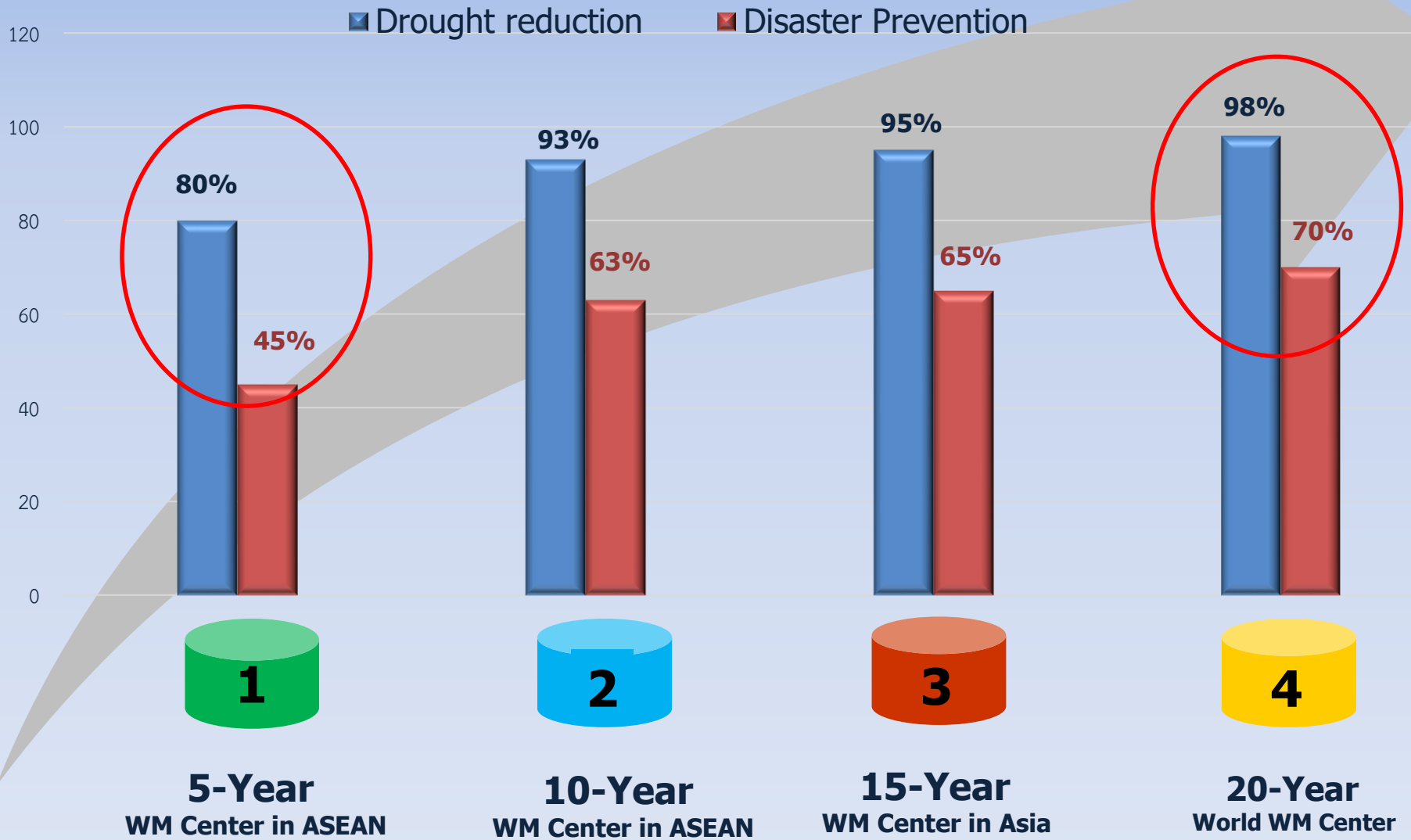
**Drought and Disaster
Prevention/Reduction**

**Rainmaking
Technology R&D**

**Agricultural Aviation
Management**



20-Year Strategic plan



"WM Center is center for Royal Rainmaking technology transfer and Agricultural Aviation"



Annual Operation

Weather Modification Activities	Winter			Dry season			Wet season					
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct
1. Forest fire/ Haze suppression												
2. Hail suppression												
3. Rain Enhancement												
4. Increase inflow water in reservoirs												



Operation statistics in 2017

- Rainmaking operation 17 Units
- Number of operation days 148-287 days
- Achievement (Rain after operation) 98.6%
- Beneficial area 36.4 million hectare (71% of total land)
- Priority: rainfed area (80% of total agric. area)
- 25 river basins in 77 provinces



7M's SuccessFactors

- 1. Method** : Royal Rainmaking Technology
- 2. Machine** : Equipment (Aircraft, Radar)
- 3. Man** : Experience & network
- 4. Motivation** : HMK's inspiration
- 5. Management** : DRRAA
- 6. Money** : Government support
- 7. Move** : Research and development

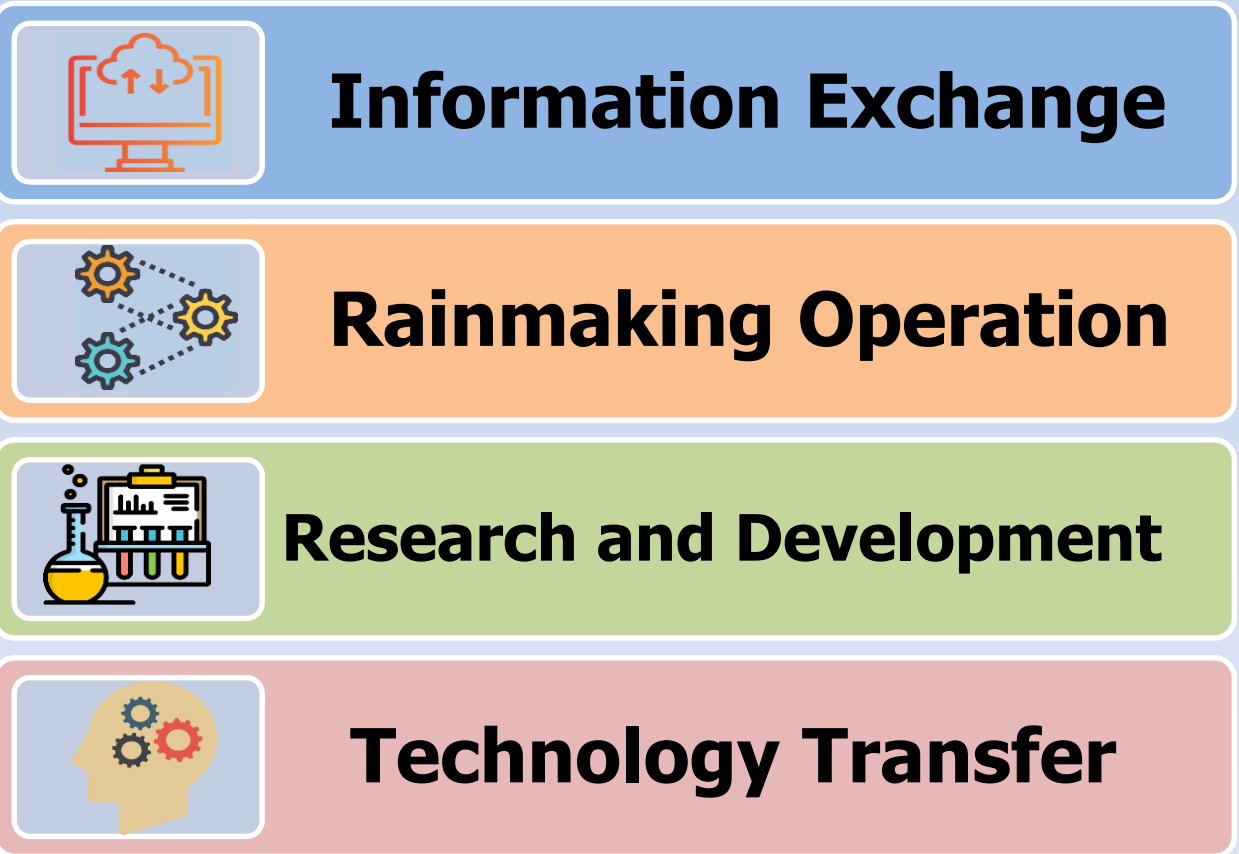
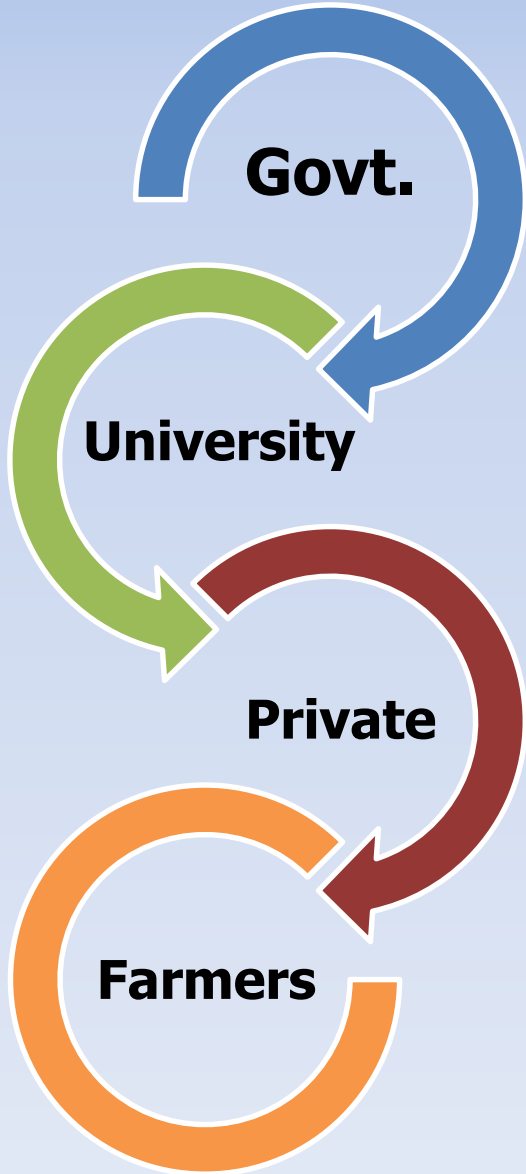
Ongoing Research Examples

- R³⁺ Integrated Water Management
- Rainmaking rainfall estimation/forecast
- Weather modification rocket
- UAV for upper air observation
- Alternative cloud seeding substances
- Improvement of automatic seeding mechanic
- Inversion layer study for haze suppression





Rainmaking Network



Integrated Water Management Network

Rainmaking and Forest Management

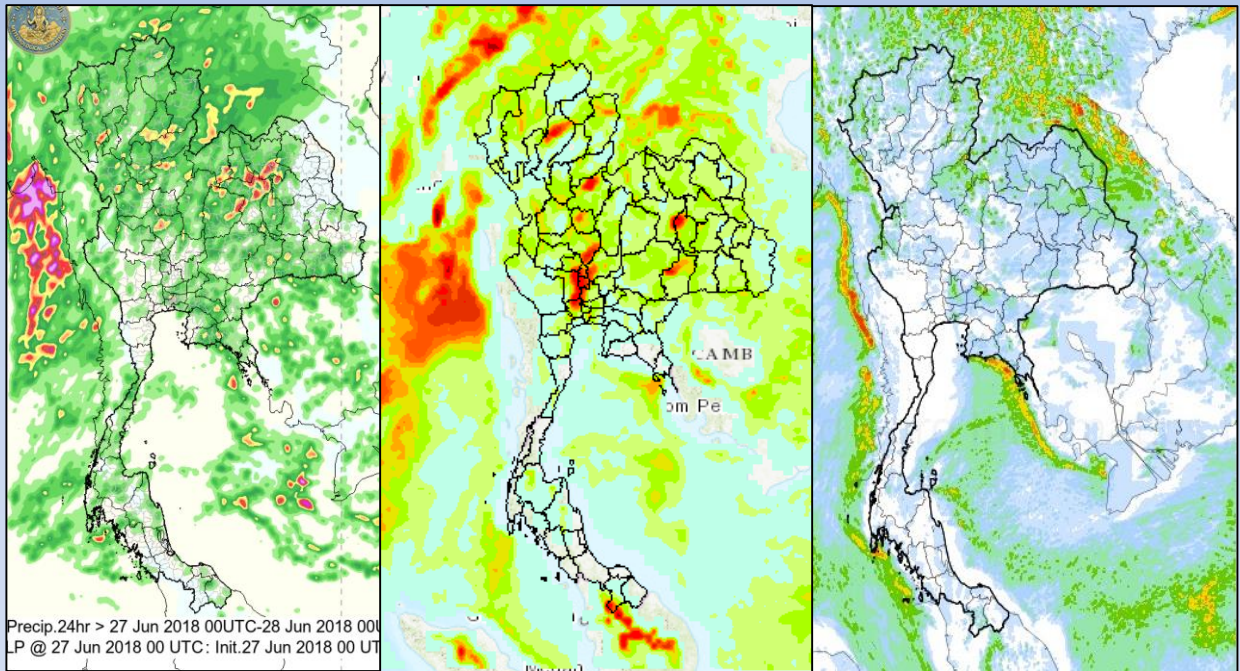
Surface water Management

Ground water Management

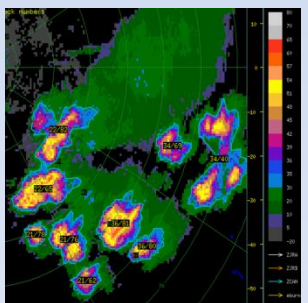
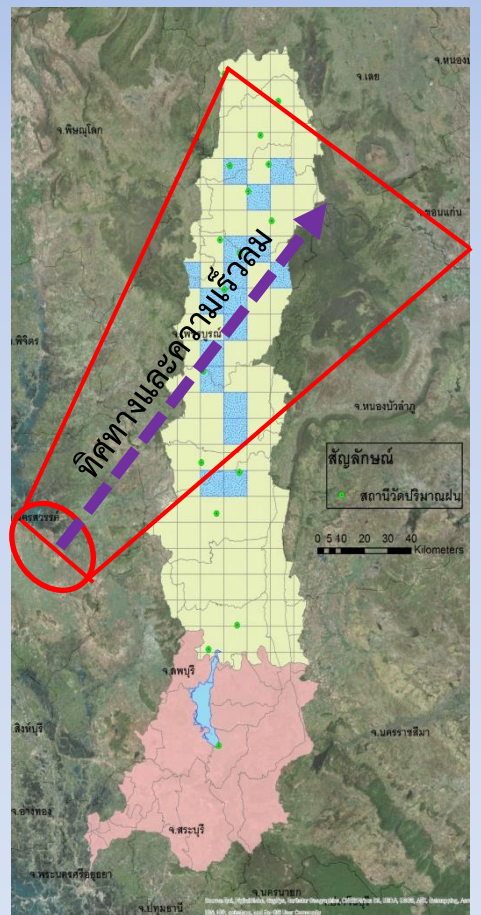


Daily Rainmaking Forecast

TMD KMITL HAIH



Fill up reservoir
 $R^2 \Rightarrow R^3 = R^{3+}$

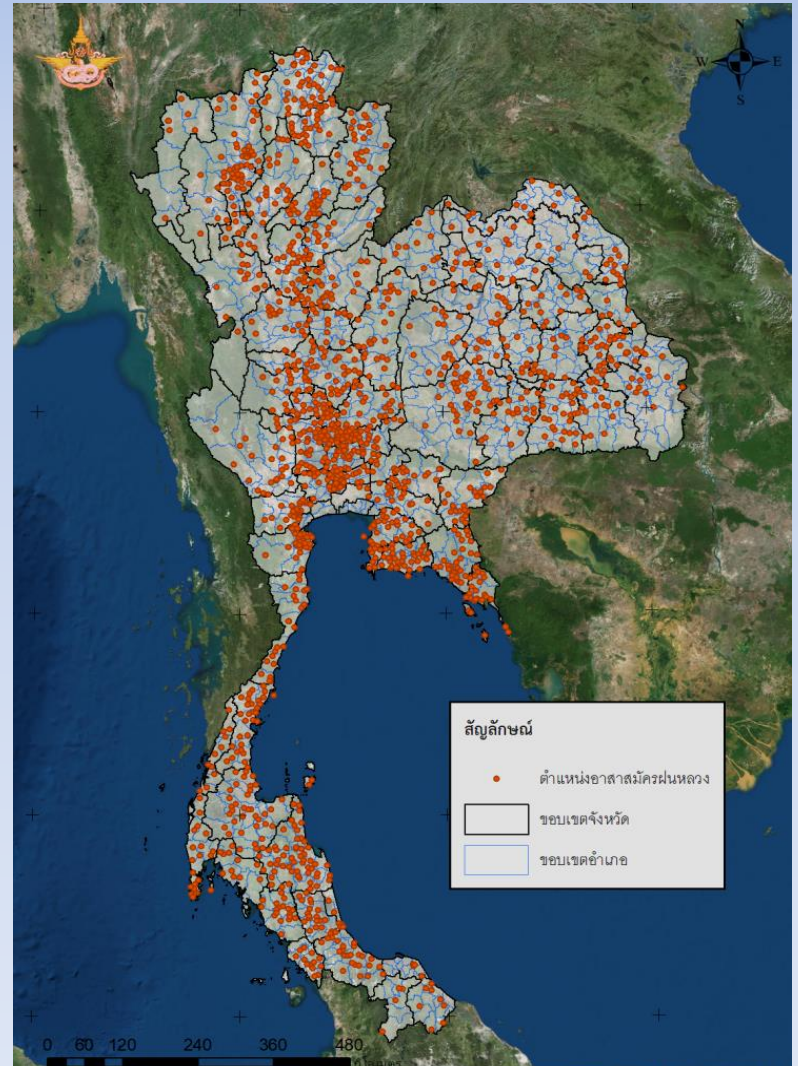


Hail Supperesion

Inflow from Rainmaking
 Pasak dam 12.4%
 Kang Kacharn dam 13.8%



Technology Transfer & Public Relations



Rainmaking volunteer = 2,527



International Cooperation



Jordan



Mongolia



Srilanka





Royal Rainmaking Technology

AgI

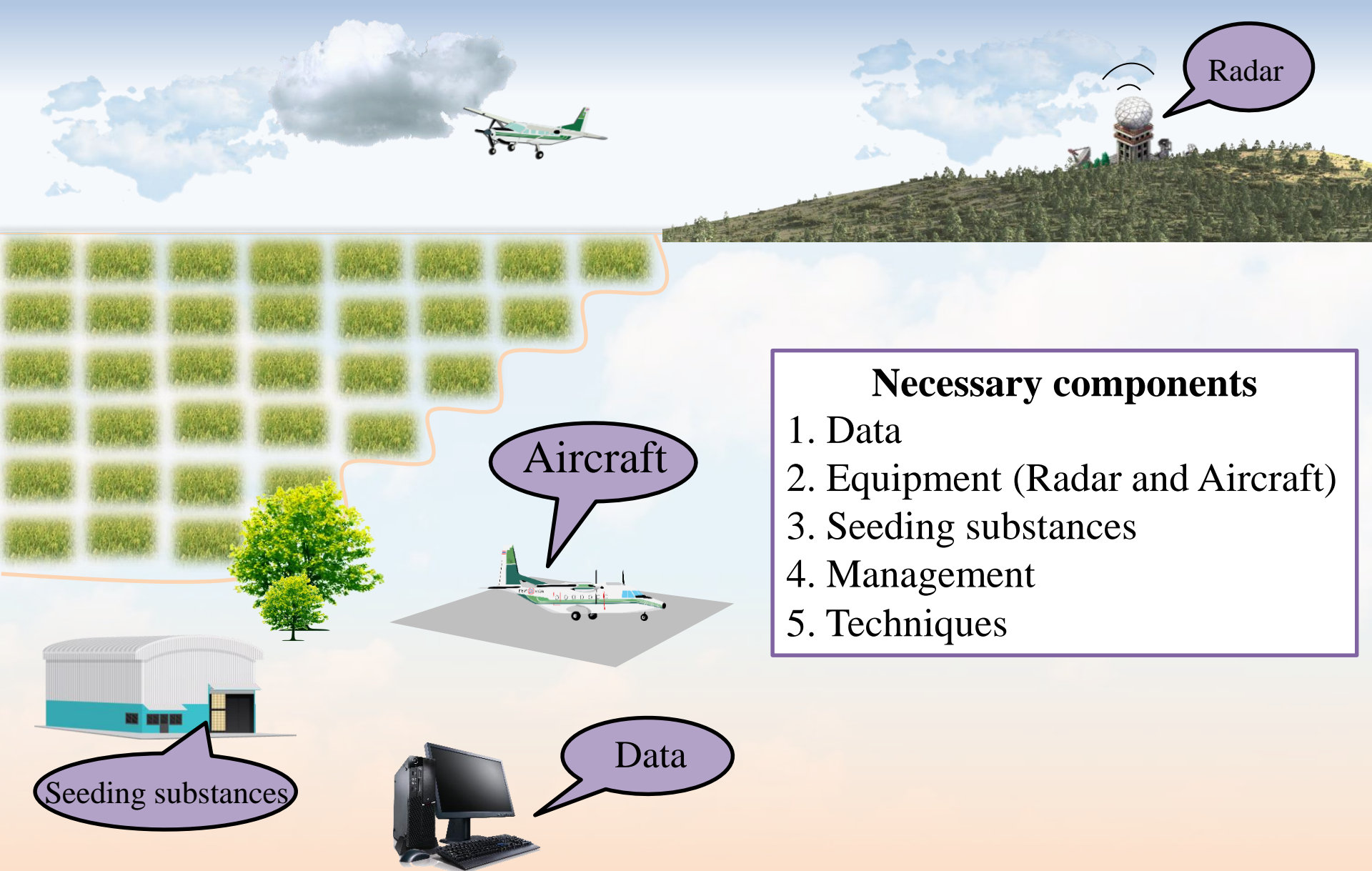
สูตร 1

สูตร 4

สูตร 3

Rainmaking Technology

Necessary components

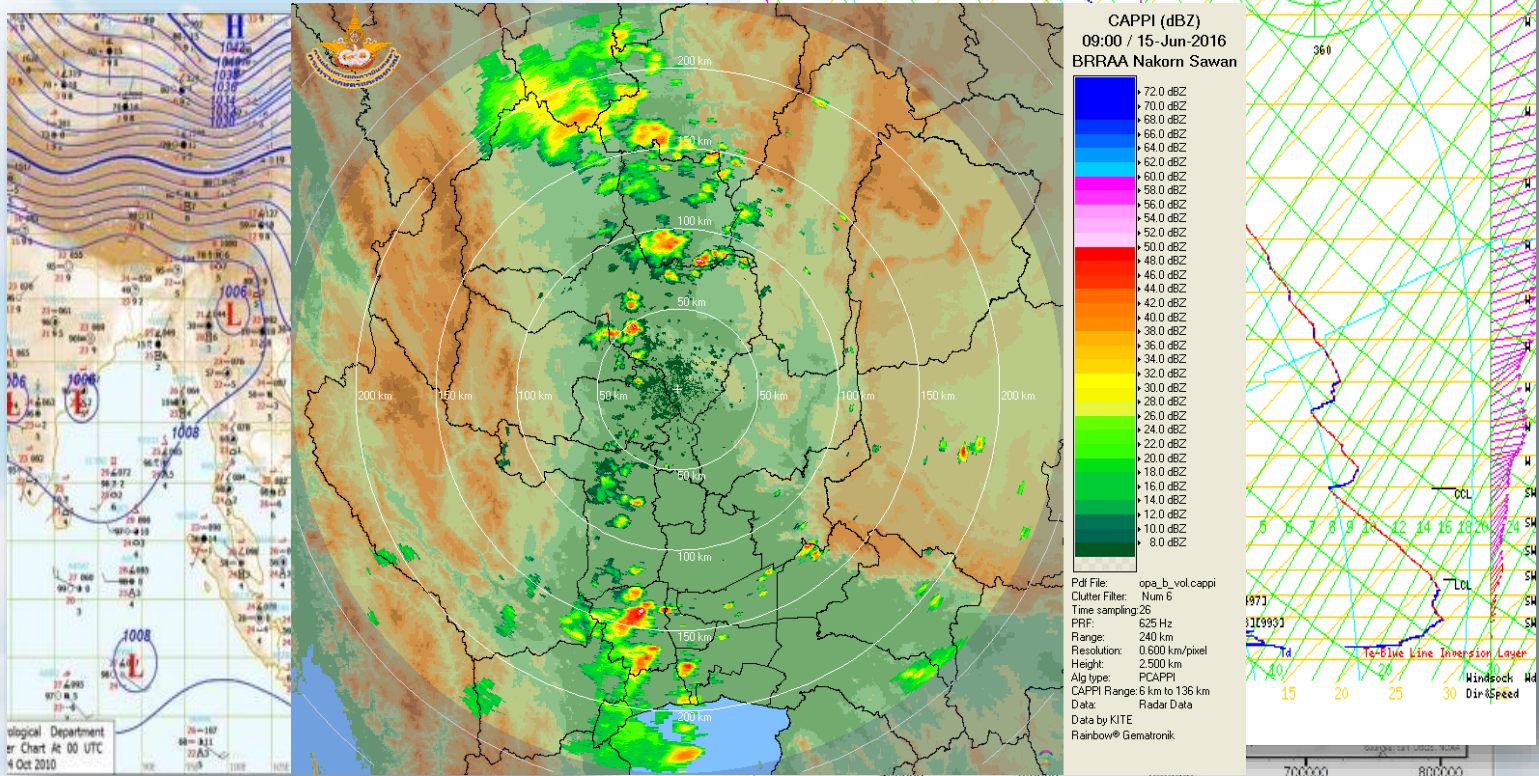
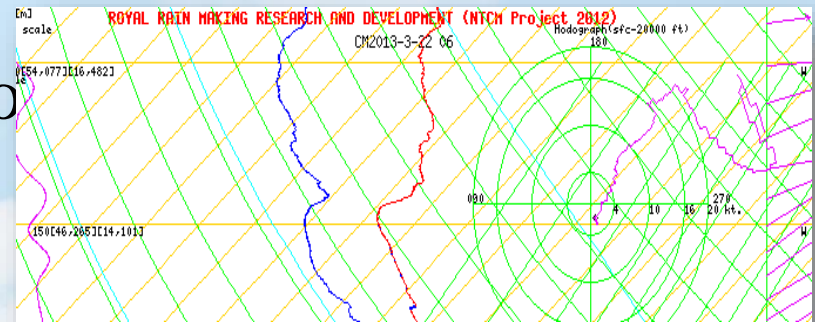


Necessary components

1. Data
2. Equipment (Radar and Aircraft)
3. Seeding substances
4. Management
5. Techniques

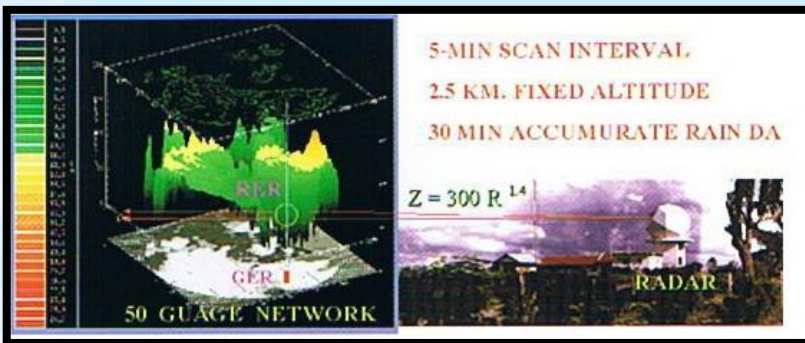
Necessary Data

- Water requirement
- Weather forecast and model
- Upper-air observation
- Radar data



Necessary Equipment

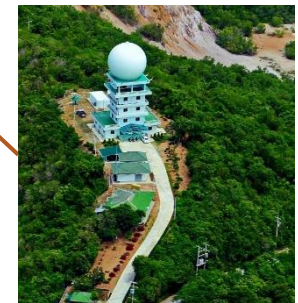
Weather Radar



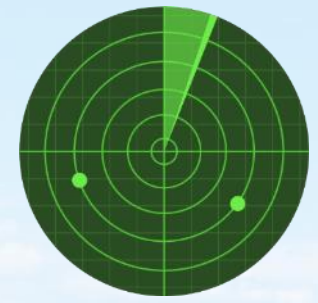
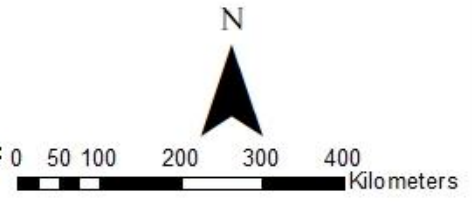


Royal Rainmaking

Department of Royal Rainmaking and Agricultural Aviation (DRRAA)



- C-Band stations
- S-Band Stations



Aircraft



<i>Type</i>	<i>Mission</i>	<i>Capacity of Loading Chemical</i>	<i>Total</i>
Helicopter	Survey	-	8
Cessna Caravan	Warm Cloud	700 – 800 Kg	12
Casa C-212	Warm Cloud	1,000 – 1,200 Kg	14
CN-235-220	Warm Cloud	2,000 – 2,500 Kg	2
King Air 350B	Cold Cloud	204 AgI Flares	3

Seeding Substances

Exothermic Chemical

Calcium Chloride (CaCl_2)

Calcium Oxide (CaO)

Endothermic Chemical

Urea ($\text{CO}(\text{NH}_2)_2$)

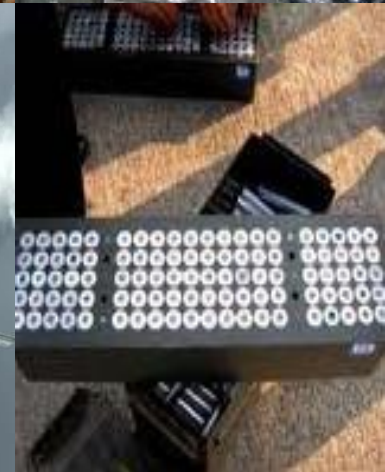
Dry Ice ($\text{CO}_2 (s)$)

Cloud Condensation Nuclei

Sodium Chloride (NaCl)

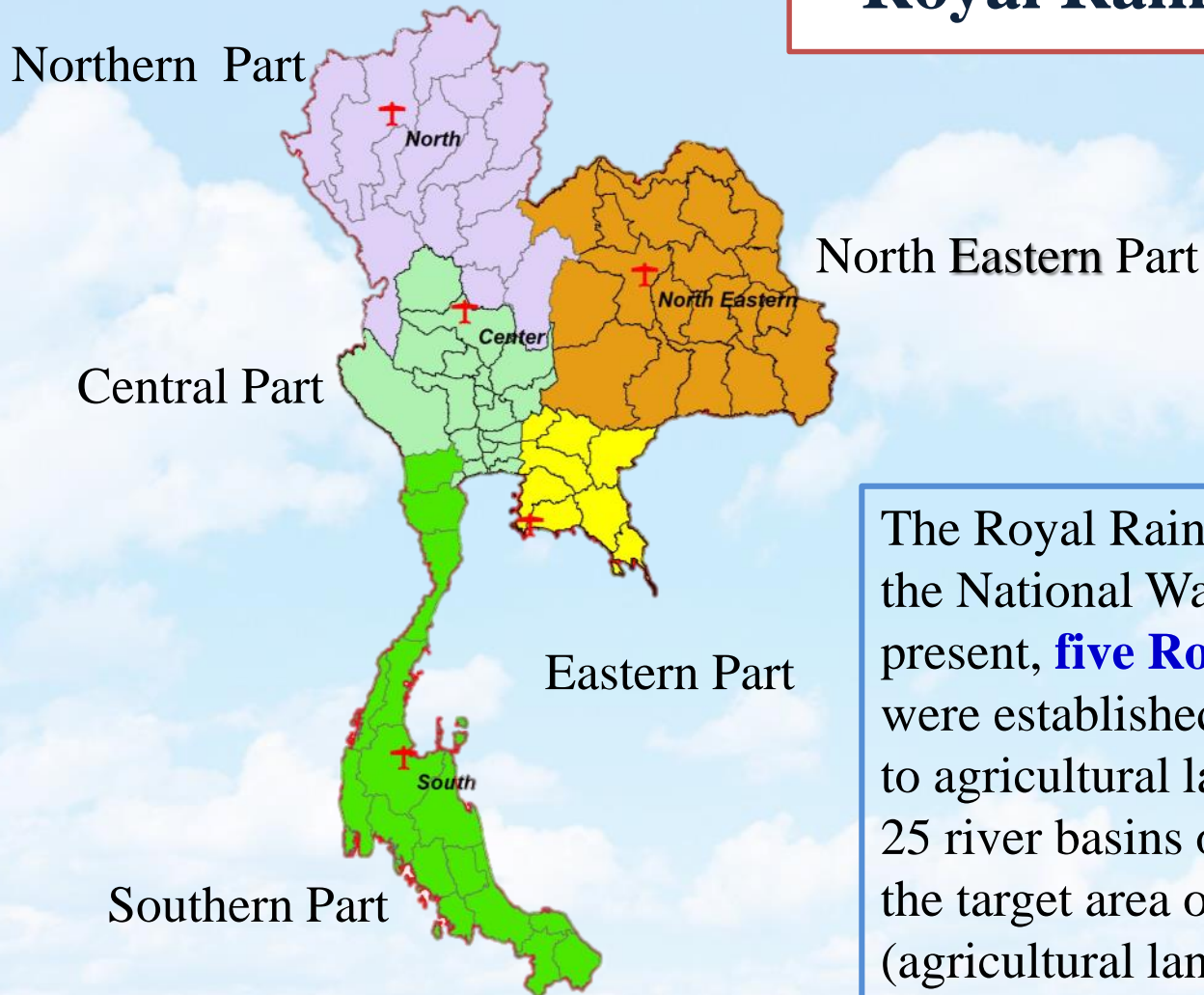
Ice Nuclei

Silver Iodide (AgI)

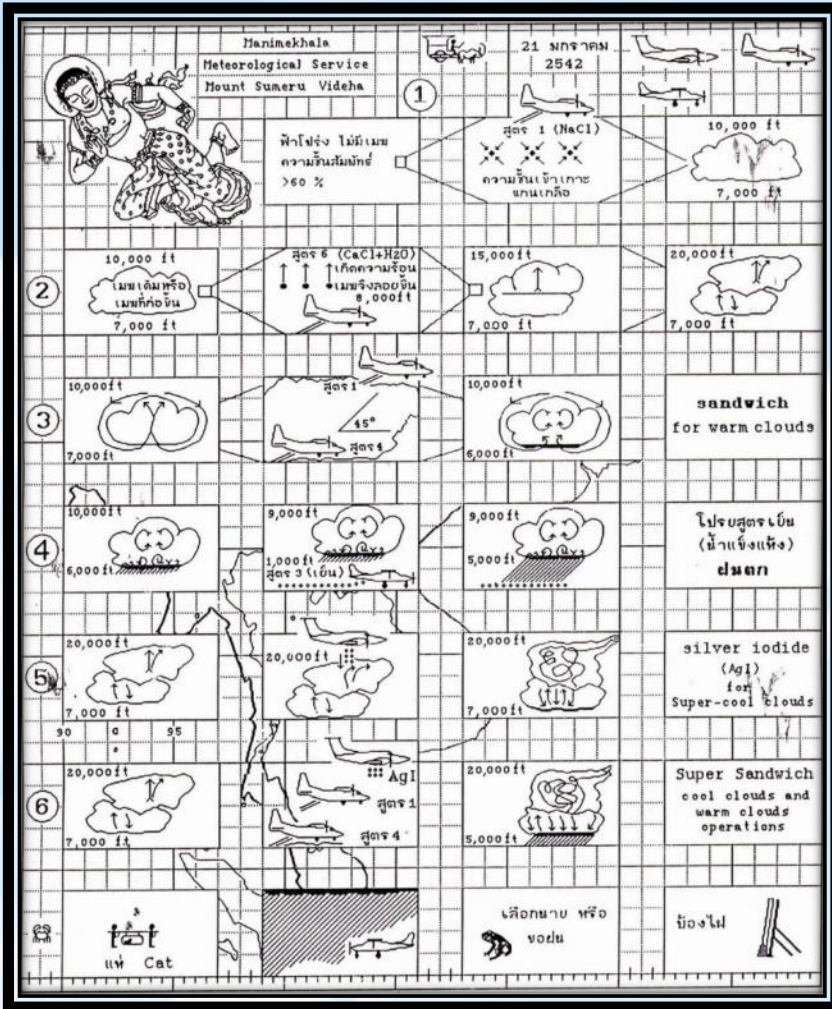


Management

Royal Rainmaking Center



The Royal Rainmaking project is a part of the National Water Management Plan. At present, **five Royal rainmaking centers** were established to add water to agricultural land, forest and reservoirs in 25 river basins of the country which covers the target area of 92 million acre (agricultural land 60 million acre)



Rainmaking Handbook



Daily Operation VDO

Seeding Experimental Results



The Applied Atmospheric Resources Research Program (AARRP) involved the conduct and evaluation of the randomized warm-cloud and cold-cloud seeding experiments during 1991-1997 in the Bhumibhol catchments area in northwestern Thailand.

Seeding Experimental Results

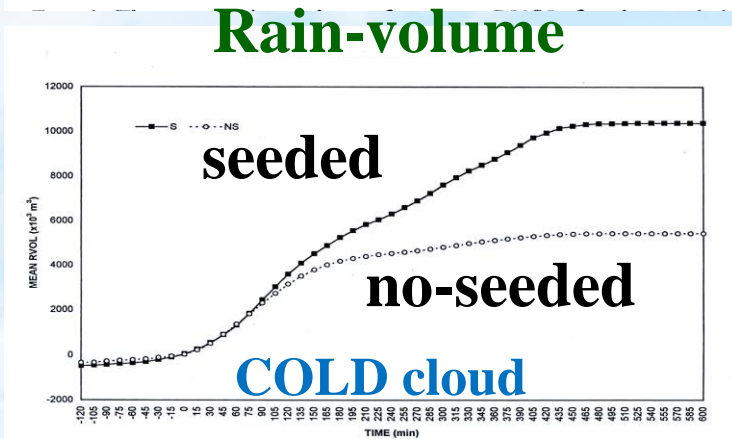
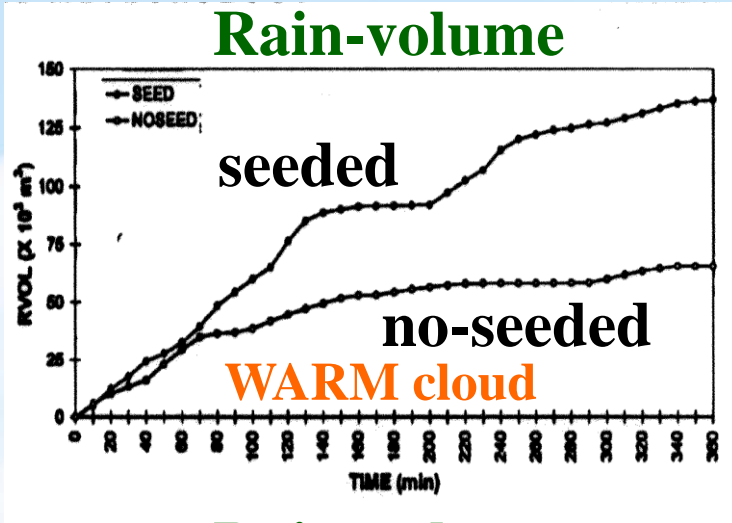


Figure 10. Plot of the mean cumulative rain-volume (MEAN RVOL) in the Seed (solid) and No Seed (dashed) units versus time relative to the time of unit qualification.

AARRP (1991-1997)

Rain	WARM	COLD
Volume	109	58
Area	84	24
Duration	11	6

% increase over no-seed

Thank you