THAILAND

The Application of Ground Based Generator Technology (GBG) for Royal Rainmaking Operation in Thailand

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Presentation Topic

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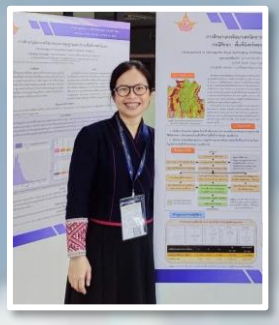

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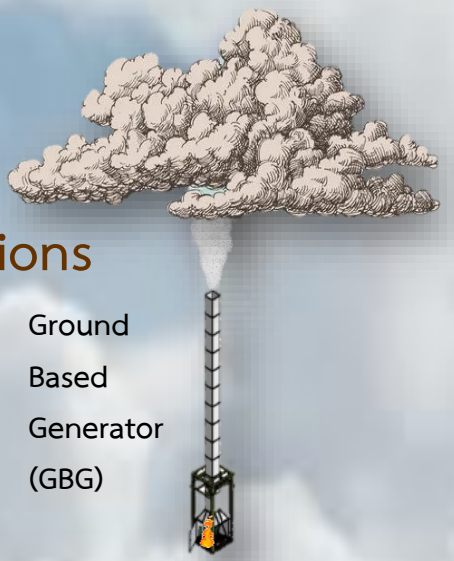
- Why should ground-based generator (GBG) technology be implemented for rain enhancement in Thailand?
- Timeline for research to operation of rain enhancement by GBG technology in Thailand.
- Research and development period of GBG technology in Thailand.
- Extended GBG technology to rain enhancement operations in Thailand.

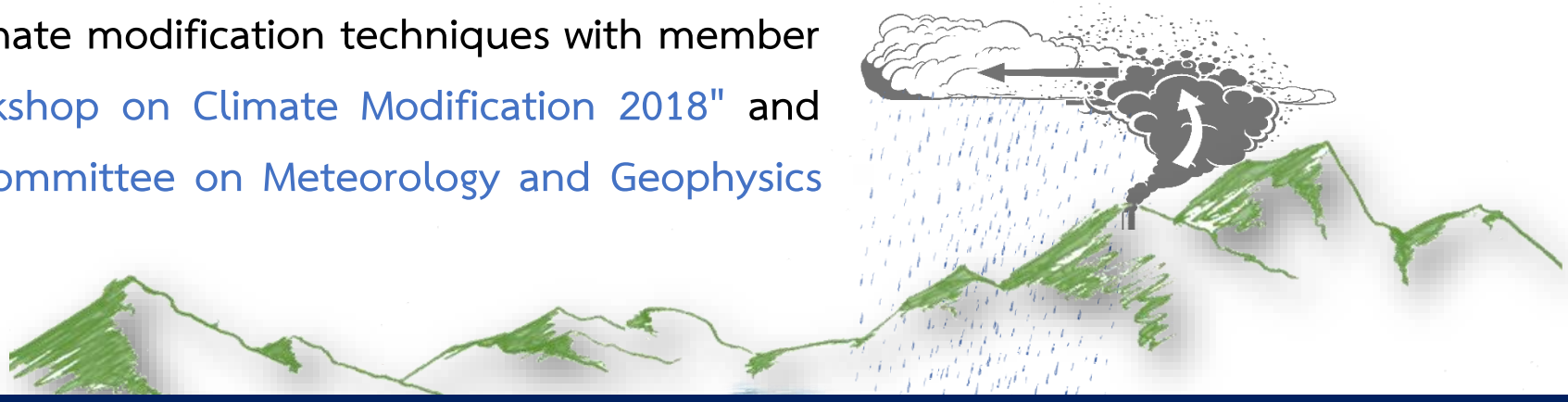


Topic 1: Why should GBG technology be implemented for rain enhancement in Thailand?

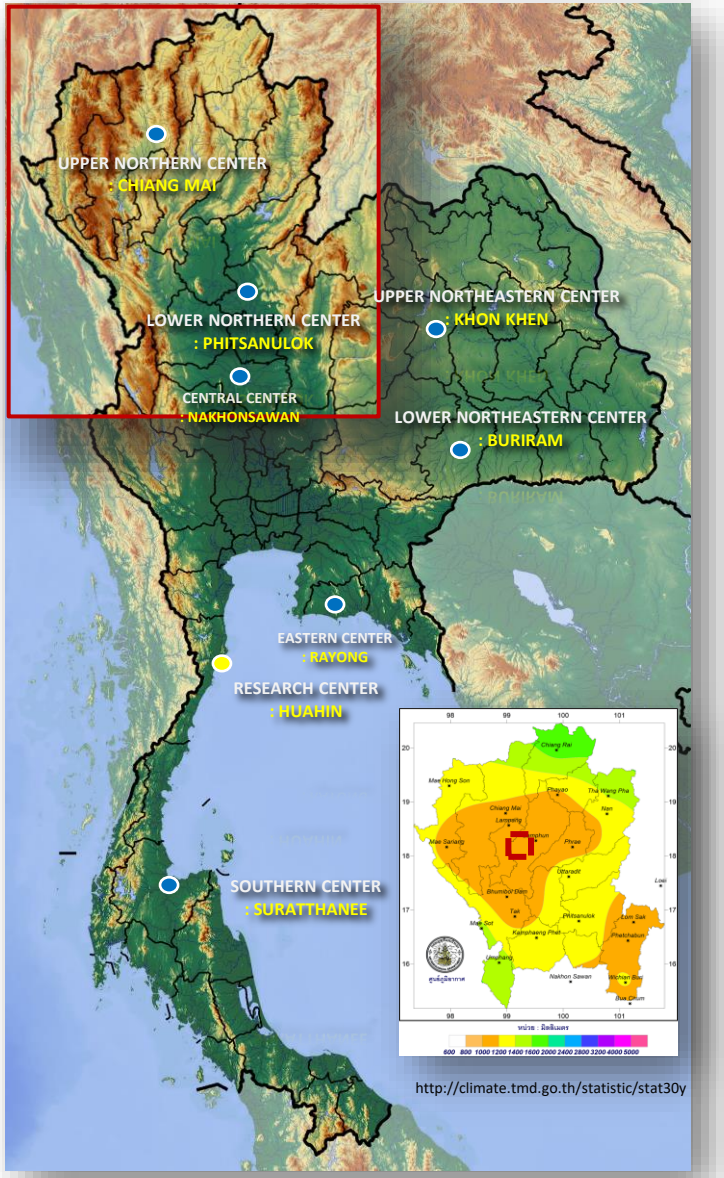
Ground-Based Generator (GBG) Technology has been utilized to enhance rainfall in various countries, particularly in mountainous areas and rain shadow regions.

Field trip to study GBG technology in Jakarta, Indonesia (August, 2018) after "ASEAN Workshop on Climate Modification 2018"

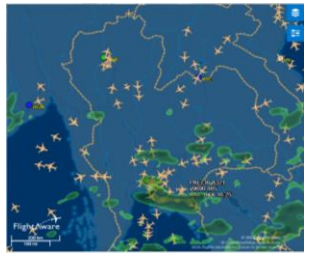
DRRAA plans to implement GBG technology for rainmaking after joining the exchange of knowledge on climate modification techniques with member countries during the "ASEAN Workshop on Climate Modification 2018" and the meeting of "The ASEAN Subcommittee on Meteorology and Geophysics (SCMG)".

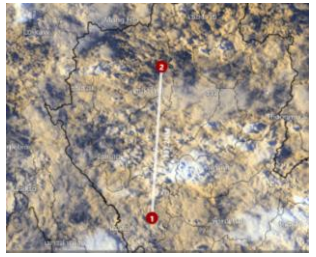


Topic 1: Why should GBG technology be implemented for rain enhancement in Thailand?



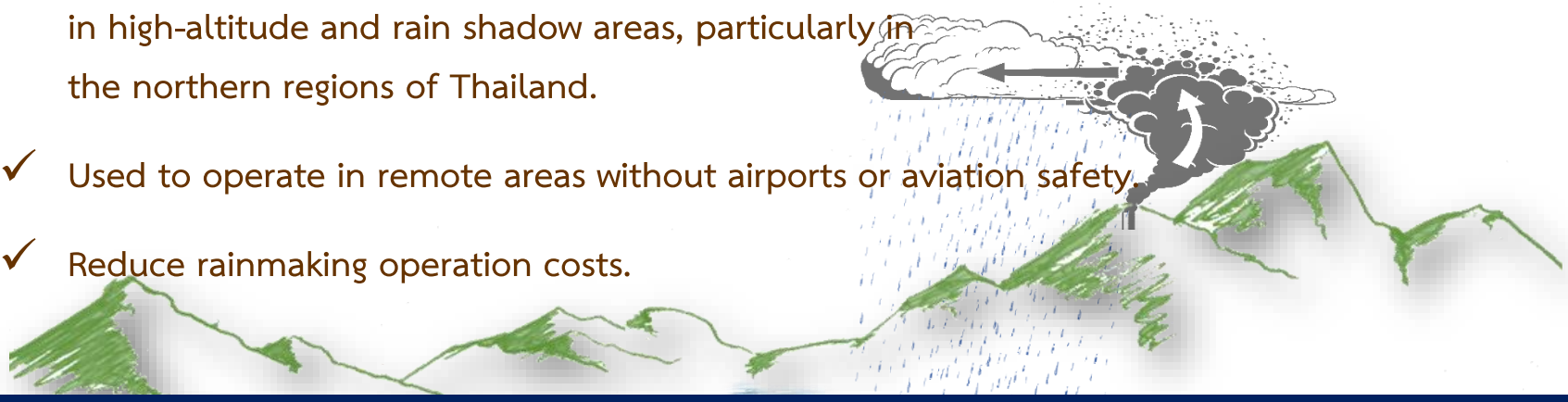
- It is unable to fly to operate in mountainous areas due to safety condition or in case of heavy air traffic as well as long distance from the airport.



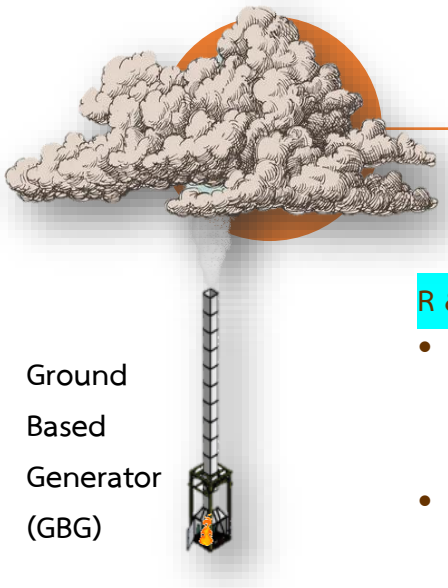


The goal of applying GBG technology in Thailand is to...

- ✓ Used as an alternative technology for making rain.
- ✓ Used for increase the effectiveness of rainmaking operations in high-altitude and rain shadow areas, particularly in the northern regions of Thailand.
- ✓ Used to operate in remote areas without airports or aviation safety.
- ✓ Reduce rainmaking operation costs.



Topic 2: Timeline for research to operation of rain enhancement by GBG technology in Thailand



Ground Based Generator (GBG)

2020 — Start to R & D

R & D Goals

- To create a GBG equipment that is appropriate for use in the specified study area.
- Design a rainmaking method using GBG technology that is appropriate for Thailand.

2022 — Finished R & D

R & D Output

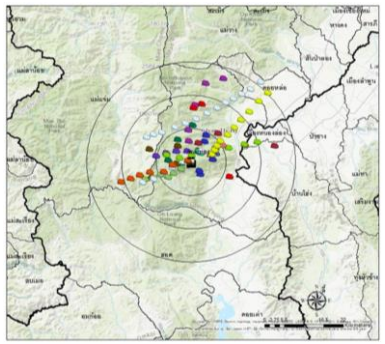
- 1 GBG equipment system
- GBG equipment system Manual
- Rainmaking operation by GBG technology manual

2022-2023 — Test Operation

- To increase the rain in the agricultural area of Chiangmai province (Chom-Thong district).
- To increase the water storage in Maekuang Udom-Thara Dam, Chiangmai province and near by agricultural area.

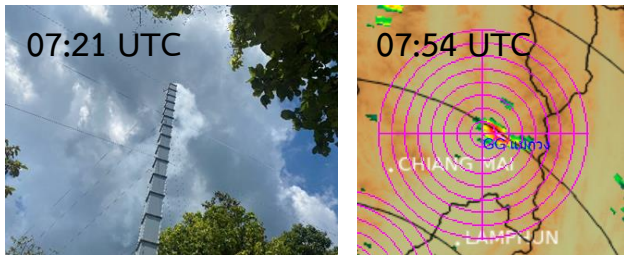
2024 — Research Utilization

- Extend utilization of GBG technology to increase efficiency in rainmaking operations in the northeast and the south of Thailand.



Chom Thong District, Chiang Mai

Mae Kuang Udom Thara Dam, Chiang Mai

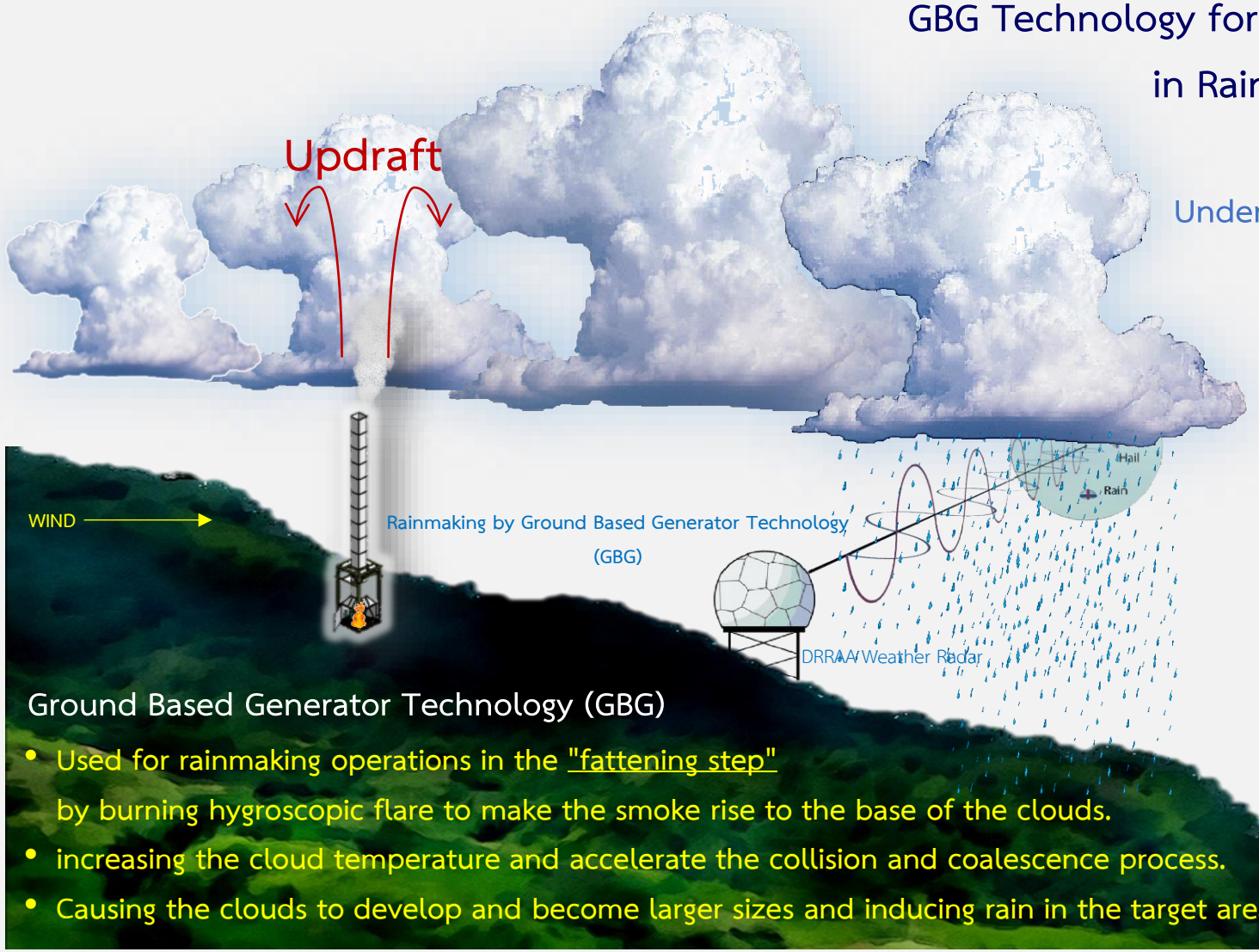


Example of rainmaking operation by GBG technology (30 May 2023)

Research and Development Project on
GBG Technology for Increase Efficiency of Royal Rainmaking Operation in Rain Shadow Area of Northern, Thailand
(2020 – 2022)

Under the cooperation of DRRAA and RDC.RTAF.

(funding from ARDA)



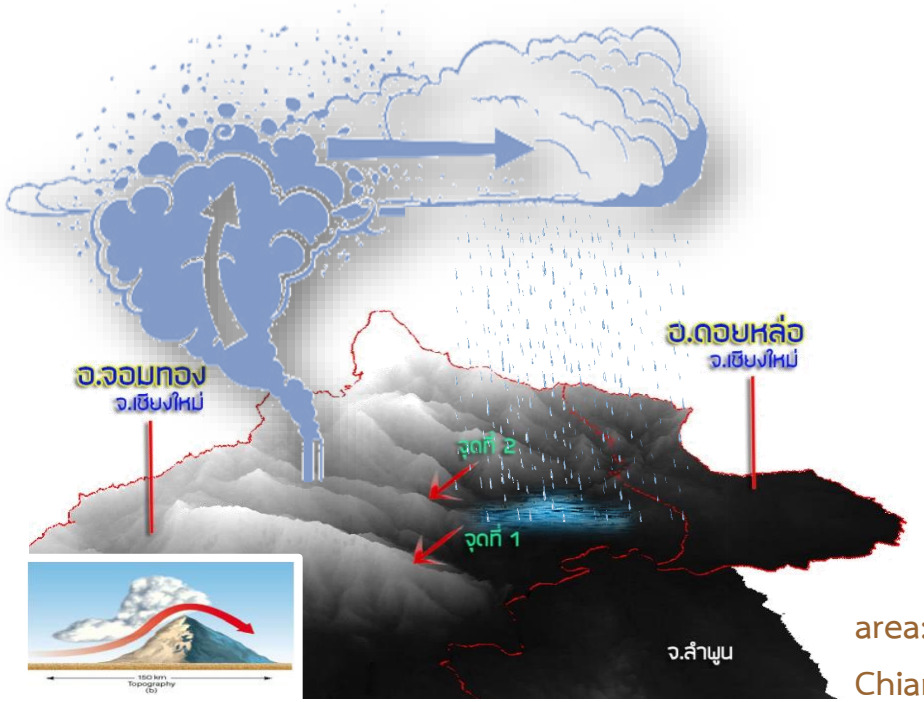
Project objectives

- To create GBG equipment that is appropriate for use in the specified study area.
- Design a rainmaking method using GBG technology that is appropriate for Thailand.

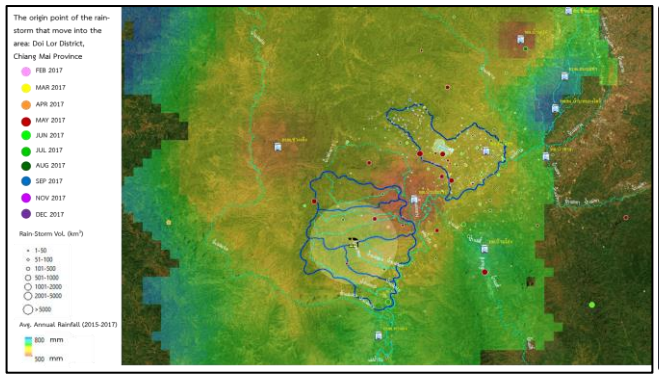
Ground Based Generator Technology (GBG)

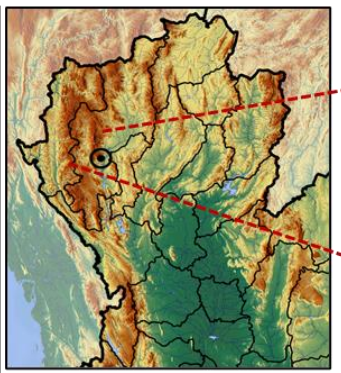
- Used for rainmaking operations in the "fattening step" by burning hygroscopic flare to make the smoke rise to the base of the clouds.
- increasing the cloud temperature and accelerate the collision and coalescence process.
- Causing the clouds to develop and become larger sizes and inducing rain in the target area.

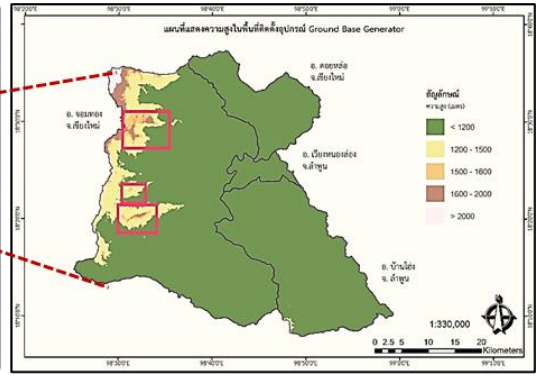
Topic 3: Research and development period of GBG technology in Thailand



area: Doi Lor District, Chiang Mai Province







START

Collect and analyze spatial data

Select area for installing GBG equipment

Analyze information about GBG technology.

Design and Prototype the GBG equipment system

Install GBG equipment in the study area

Collect radar data

Study the behavior of rain storm in the study area

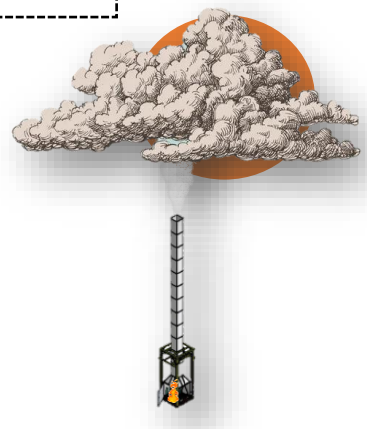
- Climatology Analysis
- TITAN

Establish the criteria for determining initial testing procedures

Testing rainmaking with GBG technology

Data analysis and conclusion

END

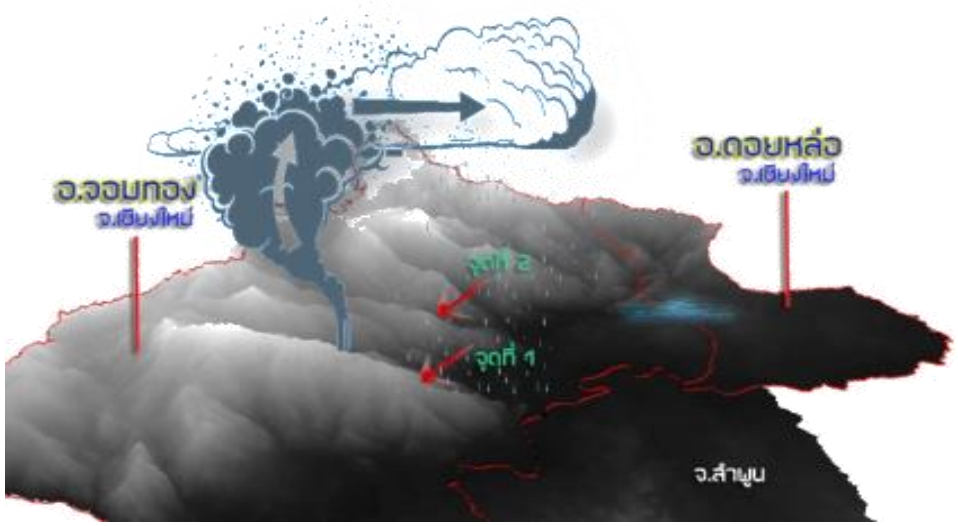


- **Survey and collect field data**

  For example, topography, elevation, land use, and agricultural water requirements.

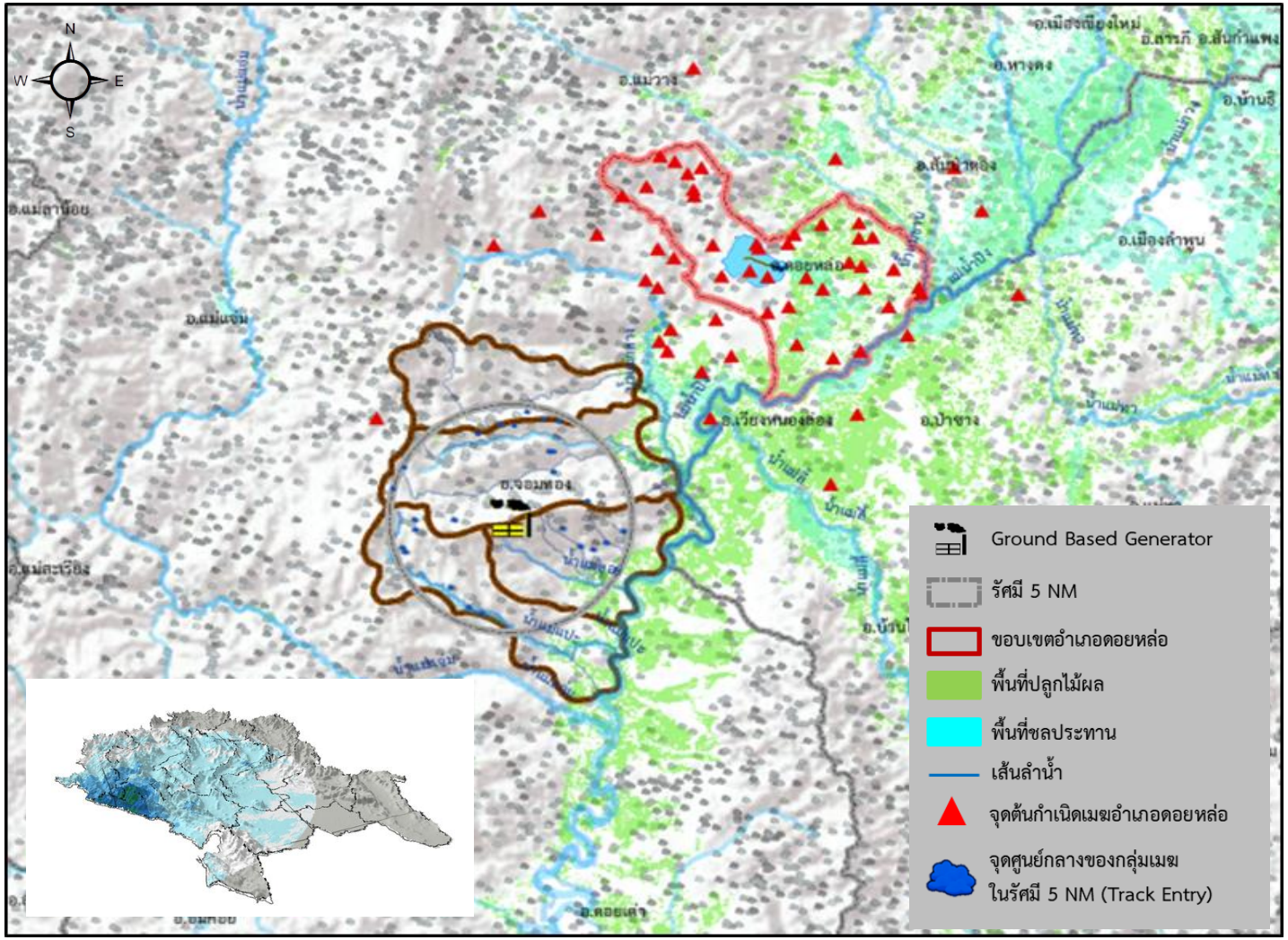
- **Study the behavior of clouds in the target area**
- **Select the installation points of the equipment set using the following criteria for consideration**
  - Location in the upwind area.
  - There is a height level of the area that can release $CaCl_2$ plume into the cloud base.
  - The area has to be convenient to install/move.
  - There is an infrastructure system that supports activities, installation, and use of equipment
  - Permission to access the area

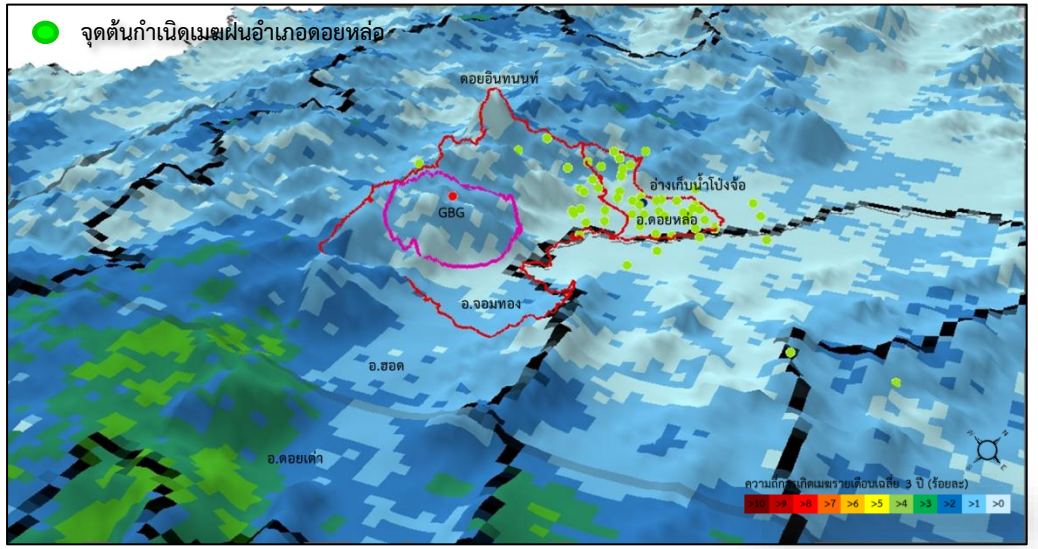
GBG
SITE SELECTION

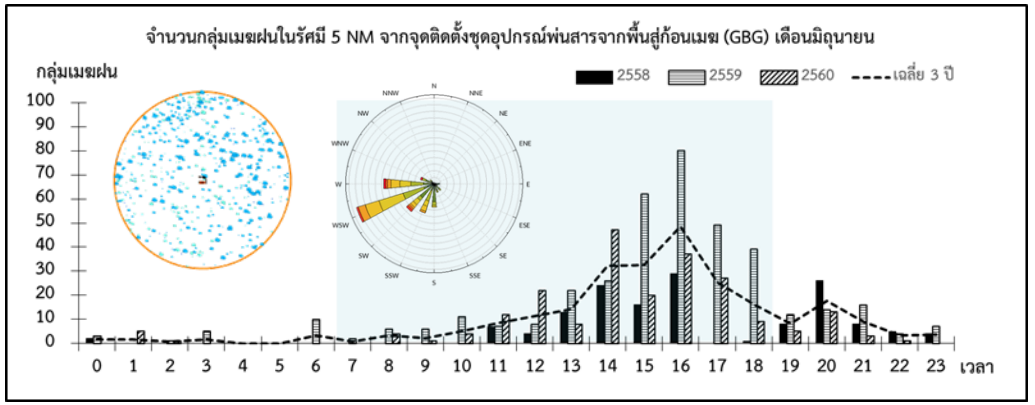


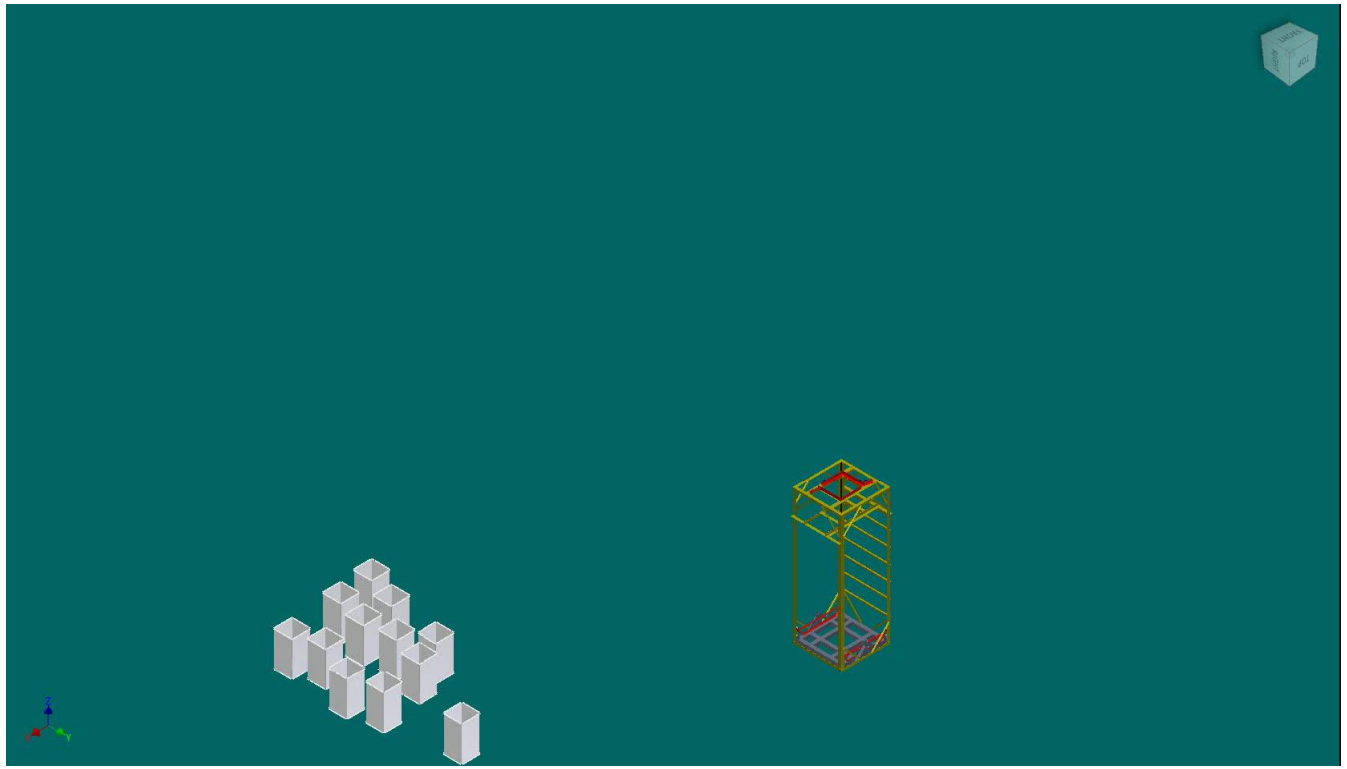
GROUND BASED GENERATOR

Examples of rain storm behavior in the study area in June









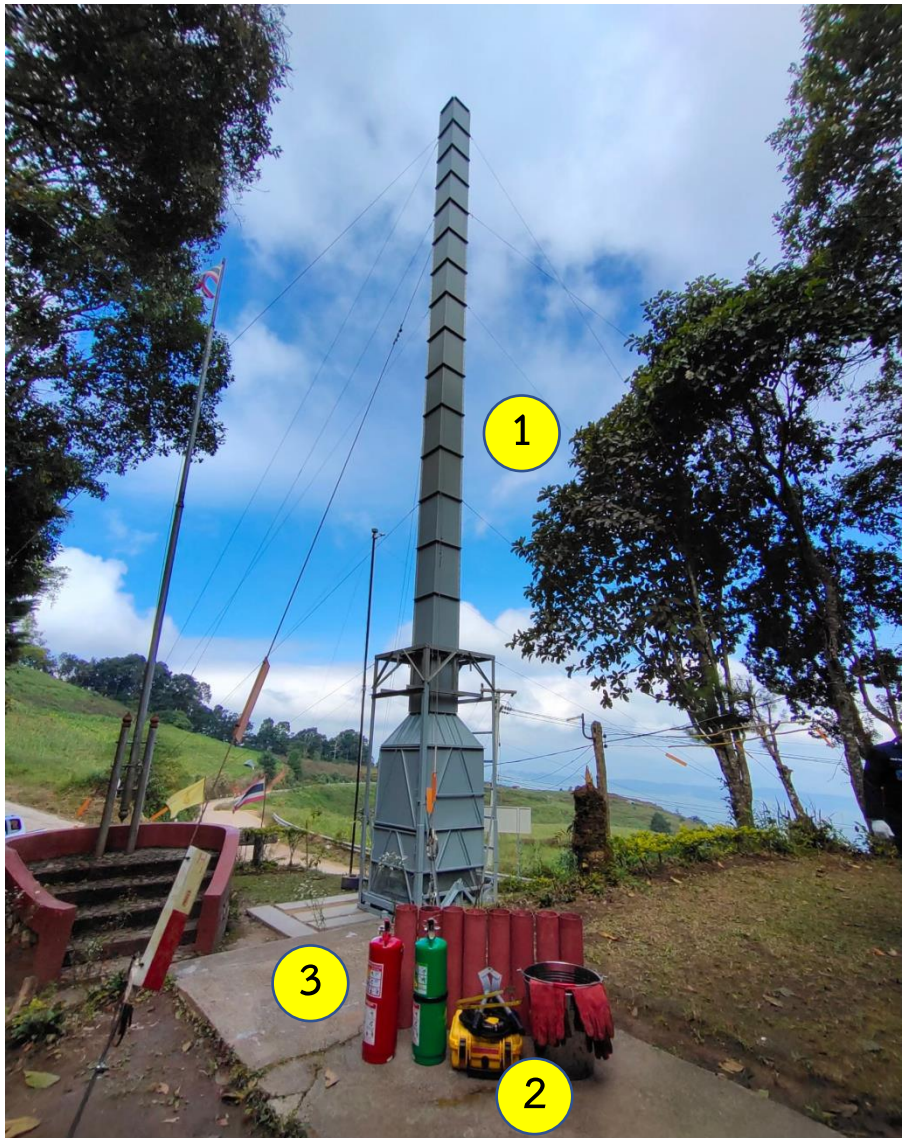
- Design and Prototype the GBG equipment system
- Install GBG equipment in the study area

Topic 3: Research and development period of GBG technology in Thailand

1. Structure :
- Height is 22.28 meters
- The combustion chamber uses a 316L stainless steel sheet
- 45 degree ventilation pipe
- Aluminum material chimney comprising 16 pieces (height 1.2 meters/piece)
  (It can be disassembled and the height of the chimney can be increased)
- Anchoring Point
- Tools for installing equipment sets (Shaft Lift)
- The installation panel can hold up to 8 firecrackers

2. Electric firework system

3. Safety equipment set : Firework cover, gloves, water bucket and fire extinguisher



The Royal Rainmaking Operation Step 2 (fattening) : burning hygroscopic flare by GBG

Substance :

- Calcium Chloride Hygroscopic Flares ($CaCl_2$) : Maximum capacity is 8 flares.

Weather conditions :

- Cumulus / Stratocumulus clouds have more than 2,000 feet of a thickness from the cloud base to the top. The diameter of cloud size is not less than 5 - 10 kilometers (2-5 NM).

Pattern :

- Fire 1-2 flares (5-6 minutes/time) continuously until the cloud moves out of the radius.

Topic 3: Research and development period of GBG technology in Thailand

1. Stand by on GBG Site
   (Monitor the cloud in area)
2. Choose the number of flares that are appropriate for the cloud characteristics.
3. Record result (text ,photo and video)

- ✓ There are no affected areas.
- ✓ Equipment is ready.
- ✓ Personnel are ready.
- ✓ Weather conditions are suitable.

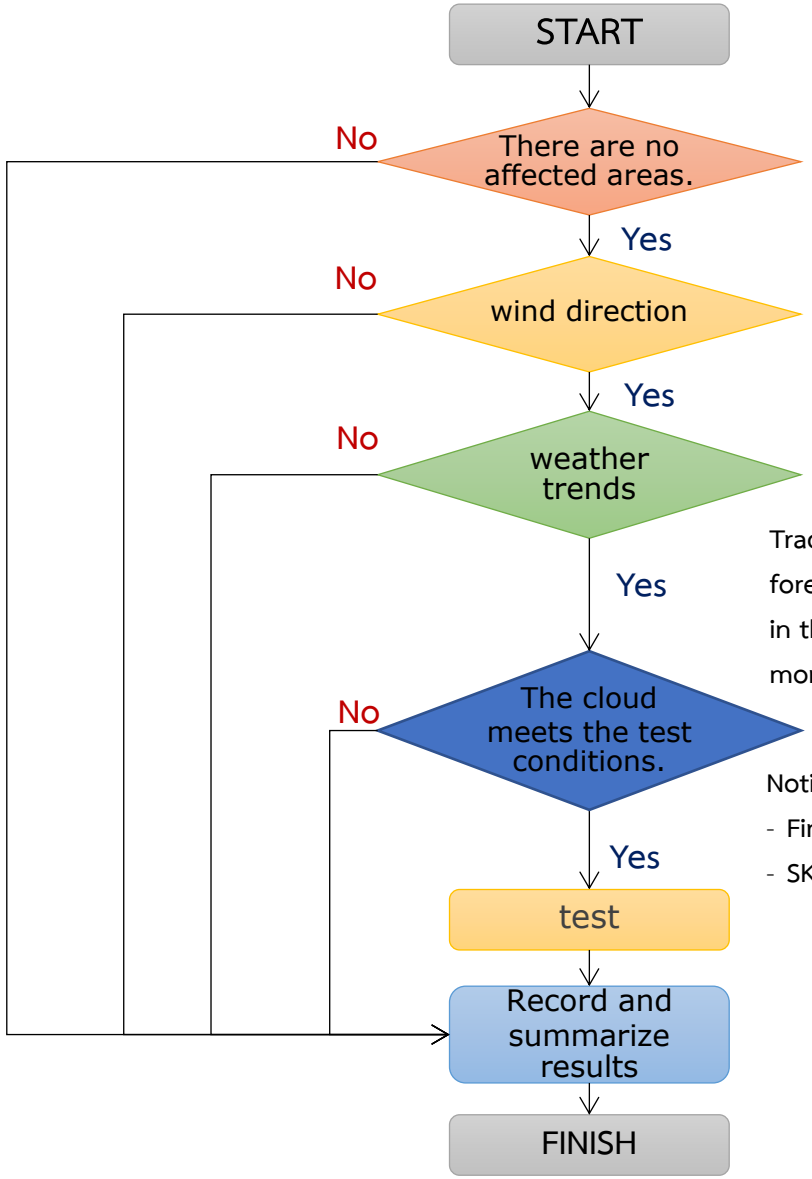
  Information : Results from upper air sounding from Omkoi/Chiang Mai Meteorological Department.

- ✓ Clouds evolve according to process of fattening (step 2)
  - Physical changes
    : size height density
    Information :Sight/Photo
  - Cloud physics changes in clouds
    Information : SKA

- ✓ There is rain in the target area.
  Information : Omkoi Royal Rain Radar / Rain Gauge

- Summary of daily results
- Problems/Obstacles

Topic 3: Research and development period of GBG technology in Thailand



Track weather conditions and forecasts Cloud development in the study area in the morning / afternoon.

Notify test plan
- Fireworks control office
- SKA team

Decision criterion of test operation

1) There are no affected areas.
2) Equipment is ready.
3) Personnel are ready.
4) Weather conditions are suitable.
5) There is a group of clouds that meet the operating conditions.
6) Number and style of flares that are appropriate to the cloud type.

Upper Air Indices		
wind	Wind.Dir 5,000-10,000 ft.	S / SW
	Wind.Sp 5,000-10,000 ft.	≤20 knots
humidity	RH 5,000-10,000 ft.	≥60%
air stability	Lifted Index	≤0
	Showalter Index	≤0
	K Index	≥30
	Sweat Index	≥200

Selection of experimental cumulus clouds

- Cumulus clouds or Stratocumulus
- Clouds Cloud base width > 5 kilometers
- Cloud thickness > 2,000 feet.
- Cloud top height < 12,000 feet.
- There should be no rain in nearby areas.

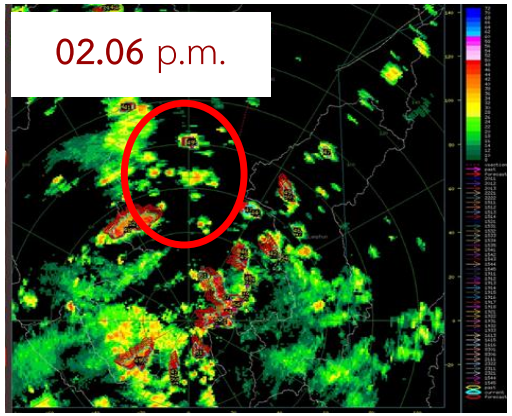
Topic 3: Research and development period of GBG technology in Thailand

Testing rainmaking with GBG technology in the study area

- Under the influence of south and southwest winds
- By burning $CaCl_2$ hygroscopic flare, 1-2 shots/time, and using 2 - 6 shots per cloud group (average 4 shots).
- with 23 groups of clouds samples.

Example of rainmaking operation using GBG : 16 July 2021

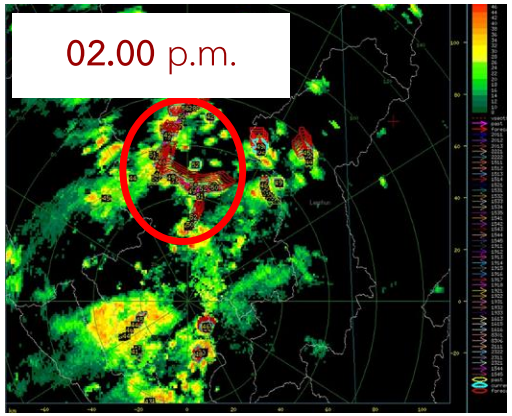
1 cloud sample: Burning $CaCl_2$ flare 4 shots (2 - 2)



Before

Operating period

After



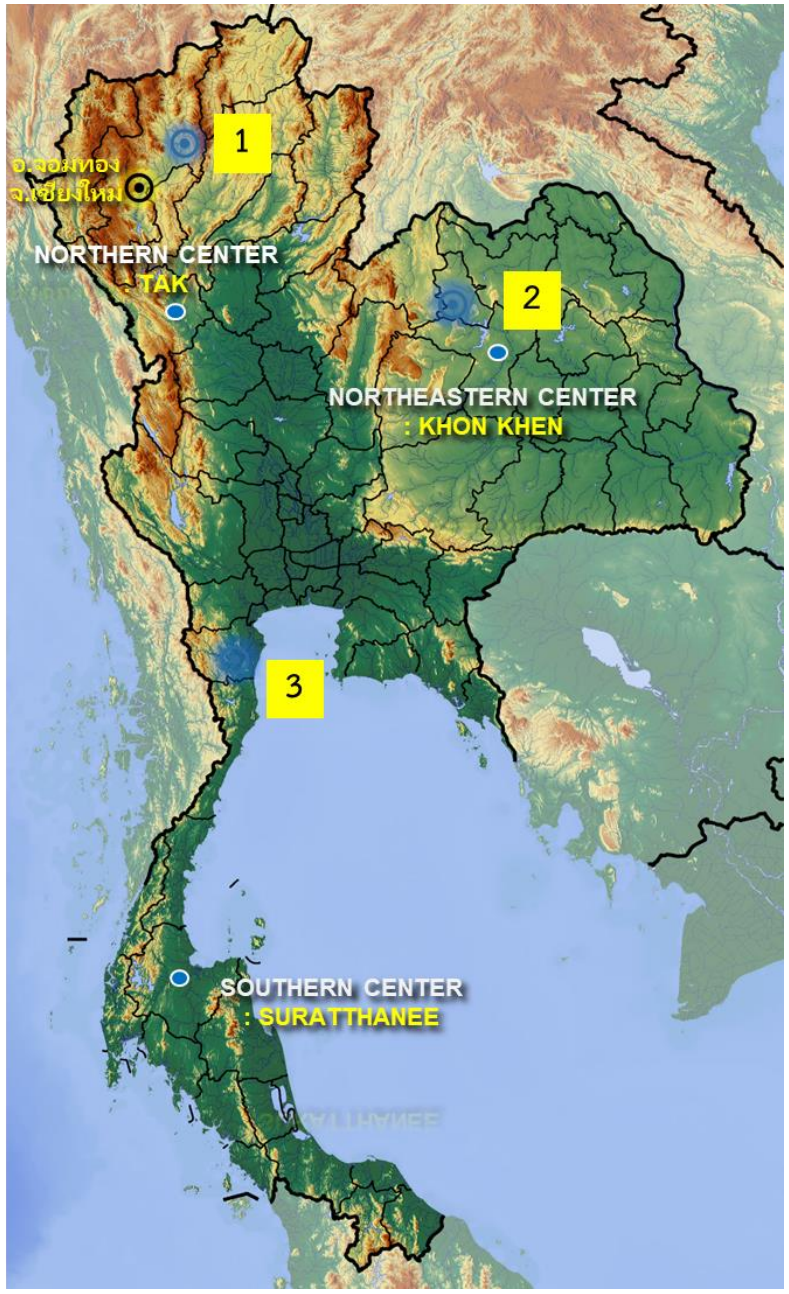
Topic 3: Research and development period of GBG technology in Thailand

Characteristics of plume released from the GBG in the study area.

It was found that :

- In most cases, the plume released from the GBG can induce the movement of air masses around the test area and causing the clouds to develop in size and density.
- Some cloud groups can fall as rain in Chiang Mai Province (Chom Thong District, Mae Chaem District, Doi Lor District) and Lamphun Province. (Ban Hong District Wiang Nong Long)
- There were 16 sample cloud groups with radar reflectance values $\geq$ 20 dBZ, representing a success of 70%.

Topic 4: Extended GBG technology to rain enhancement operations in Thailand



1. Mae Kuang Udom Thara Dam, Chiang Mai

2. Huai Luang Reservoir, Udonthani

3. Kaeng Krachan Dam, Phetchaburi

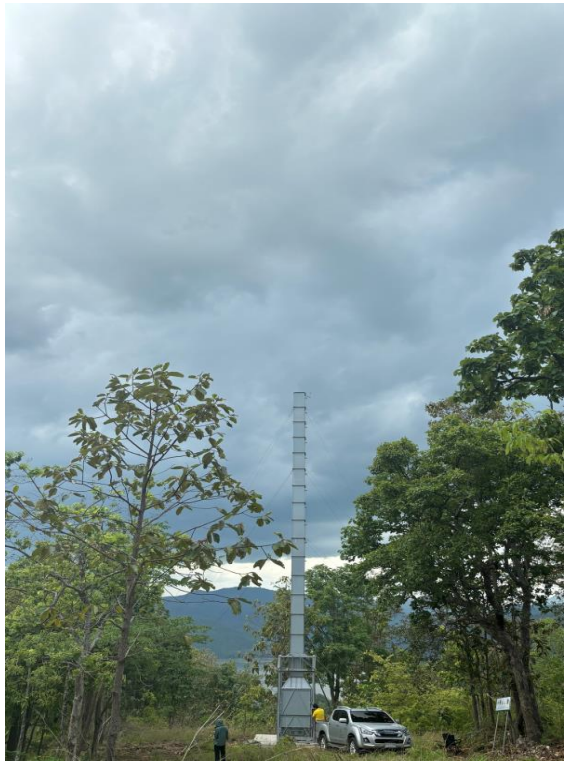
The Extension of Utilizing Ground Based Generator Technology for Royal Rainmaking Operation

Under the cooperation of DRRAA and RDC.RTAF.
(funding from ARDA in 2024)

Objectives:

1. To transfer knowledge from the research on royal rainmaking operations using Ground Based Generator technology to the scientists involved.
2. To extend the application of Ground Based Generator technology in royal rainmaking operations in the Northeast and the South.

The 1st extension site: Mae Kuang Udom Thara Dam, Chiang Mai.

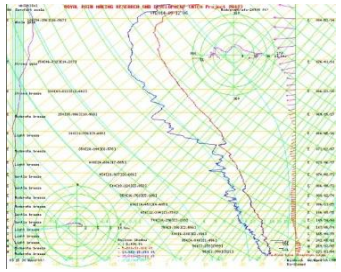
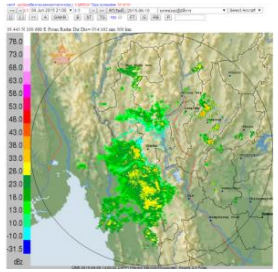


- The altitude is 2000 feet from sea level (610 meters)
- The height of GBG is 22.28 meters

Topic 4: Extended GBG technology to rain enhancement operations in Thailand

Weather Conditions



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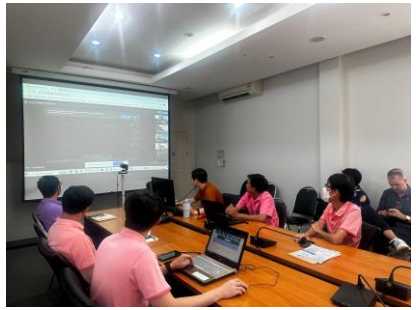
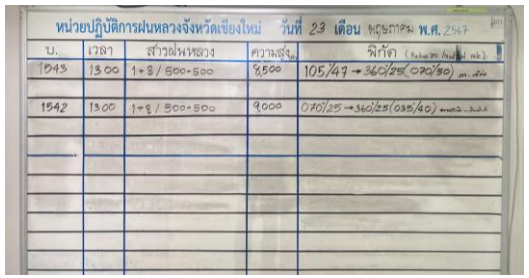
- Weather monitoring information of Upper Air Sounding Data
- Rain gauge situation
- Runoff/Dam level situation
- Disaster situation

Academic section

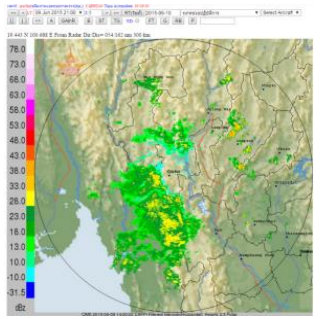
Daily meeting



Operations section

Operations

Equipment


Tracking the weather/summary of operations results

Example of rainmaking operation using GBG

at Mae Kuang Udomthara Dam, Chiangmai Province

- The Operation on June 17, 2024
- Time 02:00-03:00 p.m.
- $CaCl_2$ hygroscopic flare
  (burn 1 shot at a time, total 3 shots)

We found Stratocumulus clouds scattered around. Cloud base about 5,000 feet, move from the southwest direction. During the operation, the smoke floated to the northeast. The clouds merged into one group and developed. After the operation, rain was found moving into the target area.

Topic 4: Extended GBG technology to rain enhancement operations in Thailand

The operation on June 17, 2024

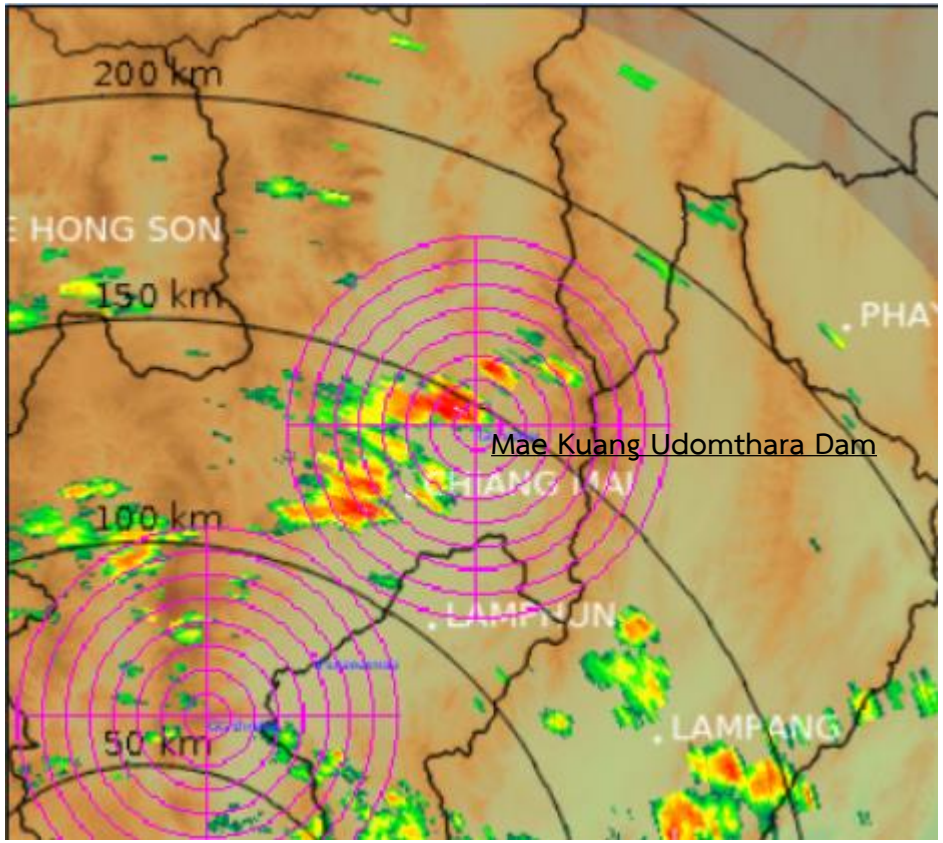
Before of the operation 02.00 p.m.

At that time 02:03 p.m.

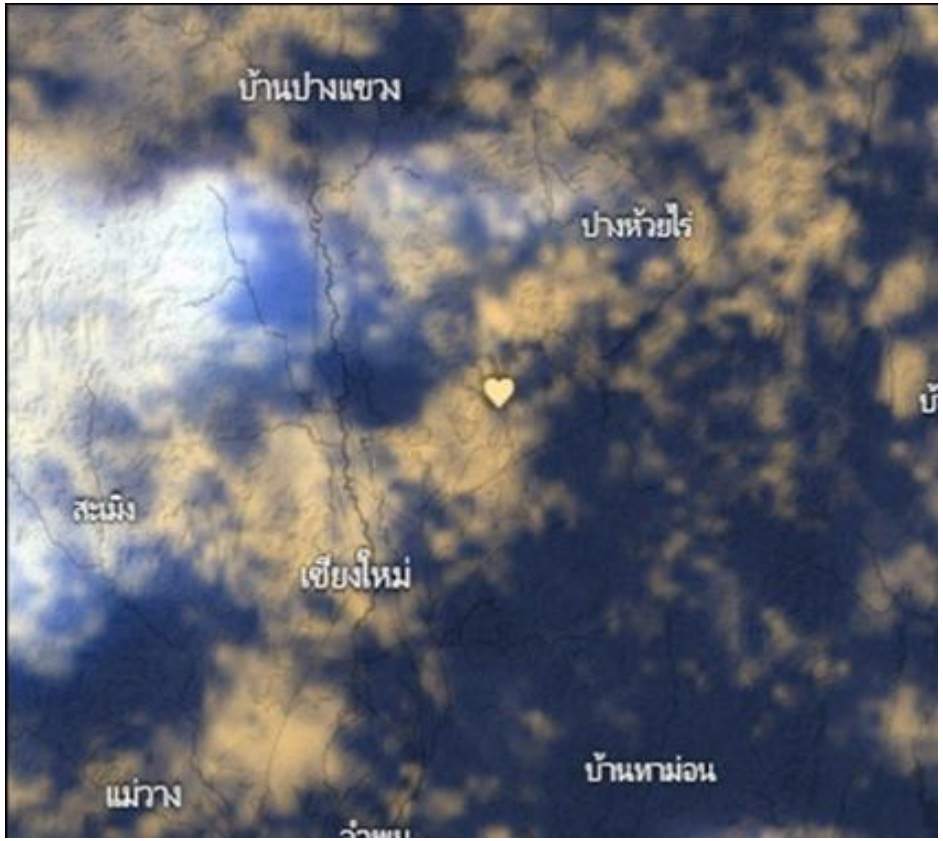
At that time 02:14 p.m.

After of the operation 02.20 p.m.

The result of operation on June 17, 2024

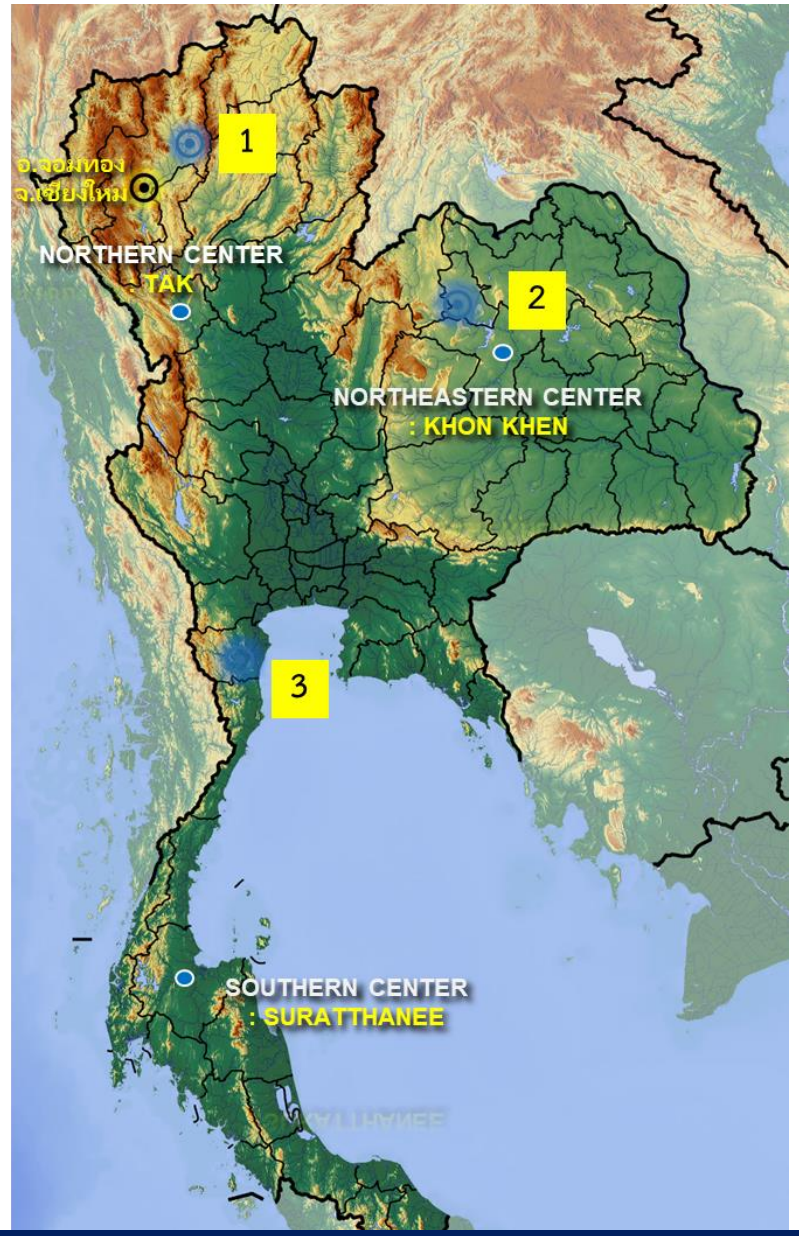


Radar image at 02.24 p.m.



Windy-Visible satellite image at 02:30 p.m.

Topic 4: Extended GBG technology to rain enhancement operations in Thailand



1. Mae Kuang Udom Thara Dam, Chiang Mai

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Next step:

1. Transfer knowledge from the research on rainmaking operations using GBG technology to the scientists involved.

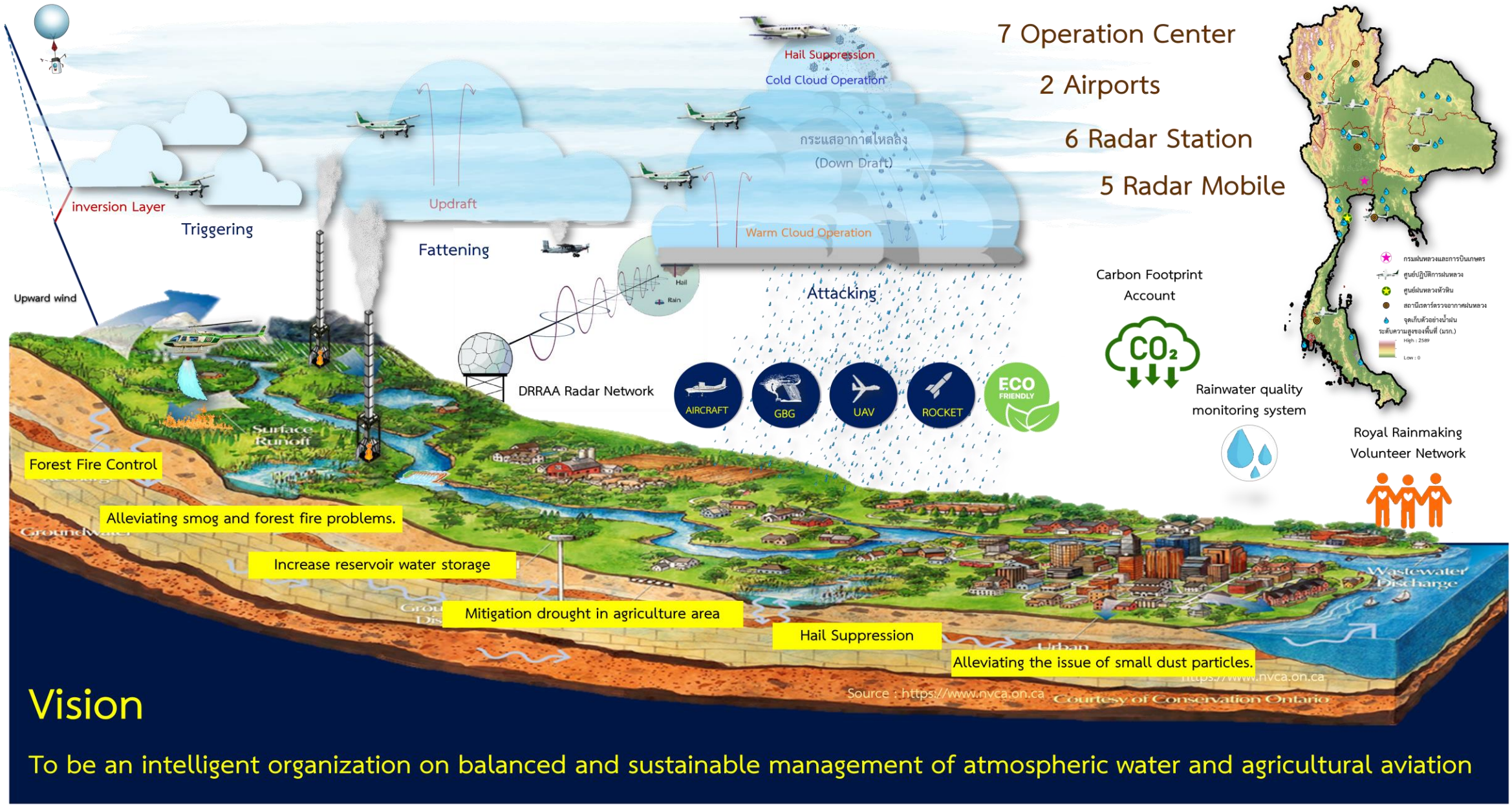
2. To extend the application of GBG technology for rainmaking operations in the Northeast and the South.

- ☑ Site survey and Select area for installing GBG equipment
- ☐ Creating GBG (in the process)
- ☐ Install GBG equipment in the extended area
- ☐ Transfer knowledge to the scientists involved (On the job training)
- ☐ Rainmaking Operation and evaluation

THANK YOU

Dealing with Natural Disasters on the Path to Sustainability

Q & A



Vision

To be an intelligent organization on balanced and sustainable management of atmospheric water and agricultural aviation