กรมฝนหลวงและการบินเกษตร

Efficiency Enhancement of Hail Suppression Operation

Royal Rainmaking Technology Research and Development Division


ลูกเห็บถล่มนครพนม


GIOba

Hail Formation

Hail Formation within the Cloud

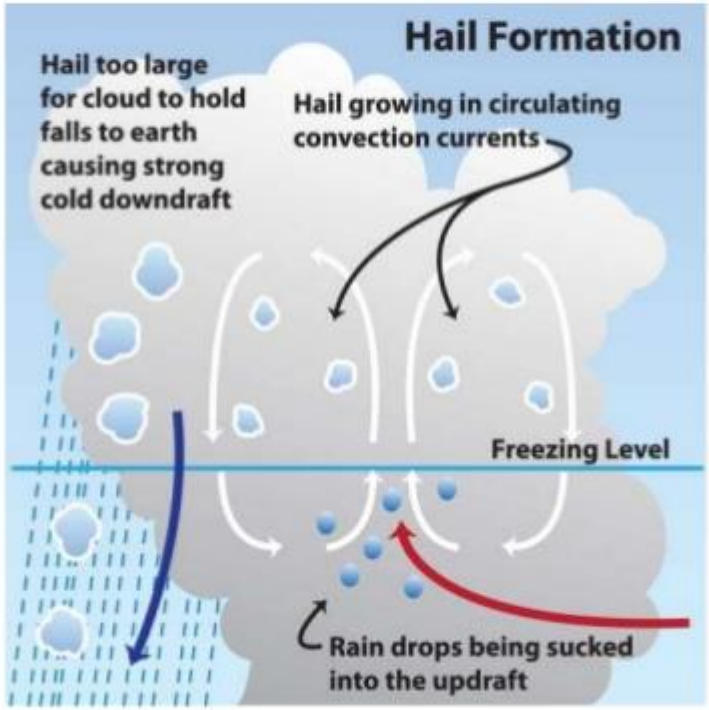
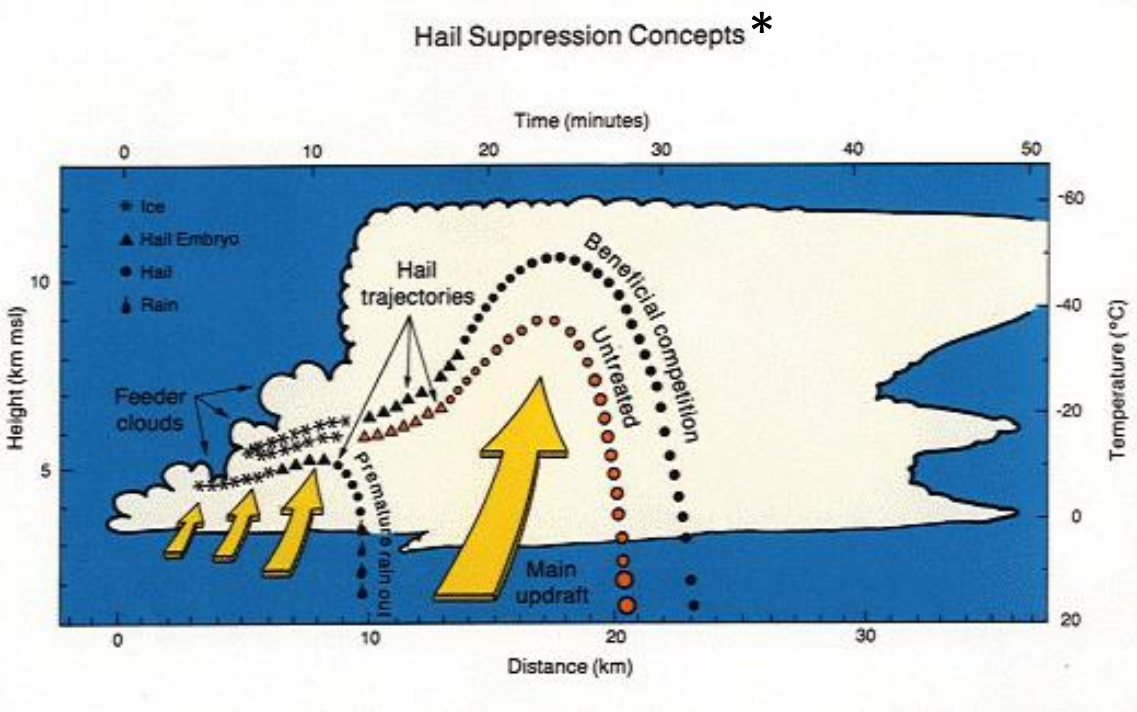


Image from NASA- http://scijinks.jpl.nasa.gov/review/rain/hail-formation-large.jpg

Hail Suppression Concept



**Reduce hailstone growth

**Produce more ice nuclei

source : *https://sites.google.com/a/ualberta.ca/hail/index/air-desc/hail-desc

**A.S. Dennis (1977)

Alpha Jet

Super King Air

Introduction

- Hail suppression is one of Royal Rainmaking mission
- Hail suppression plan : March - May
- Operation area : North and Northeast of Thailand

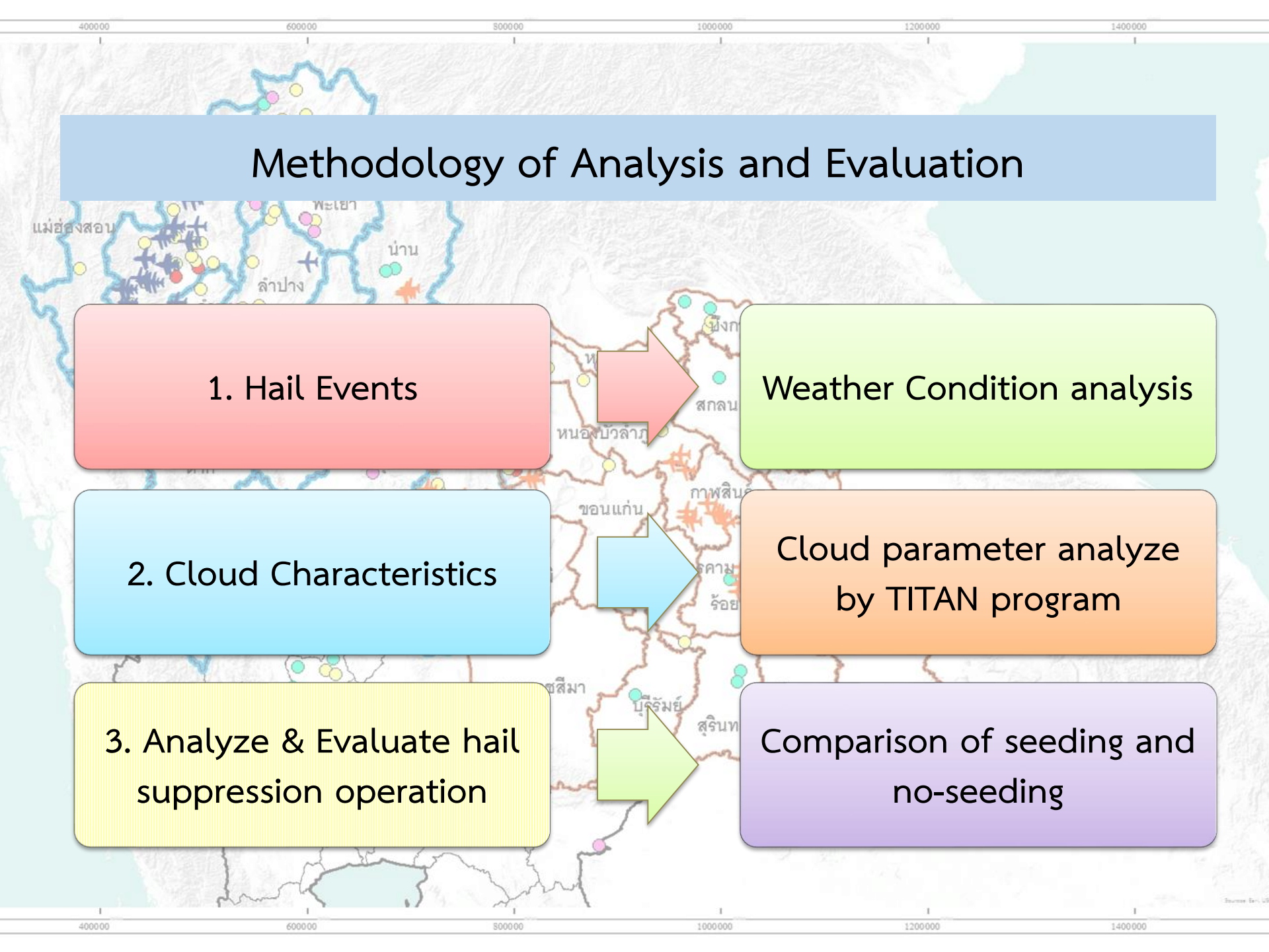
Objective

Alpha Jet

Super King Air

- Characteristics of Hail Cloud
- Analysis and Evaluation of Hail Suppression Operation

Methodology of Analysis and Evaluation



Radar Detector

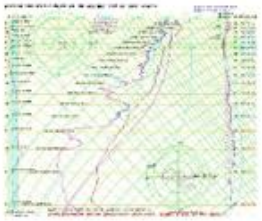
Parameter	Literature	Study*** (2017)
Z_{max} (dBz)	55*	54
VIL (kg/m^2)	25**	32
Probability of hail	-	0.3

* Klaassen W. (1988)

** Kitzmiller D.H., et al. (1995)

*** Chayathum T. (2017)

Hail Suppression Work Flow



Upper air observation

SI < -1.0

LI < -1.0

KI > 30

CAPE > 2,000 j/kg

CIN < -400

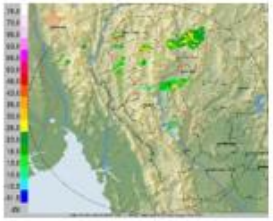
PW > 3.8 cm

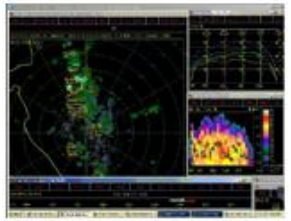
Mean RH at 0-10,000 ft >70%

Mean Wind Speed 0-15,000 ft <10 kts

Weather Analyze

Equipment



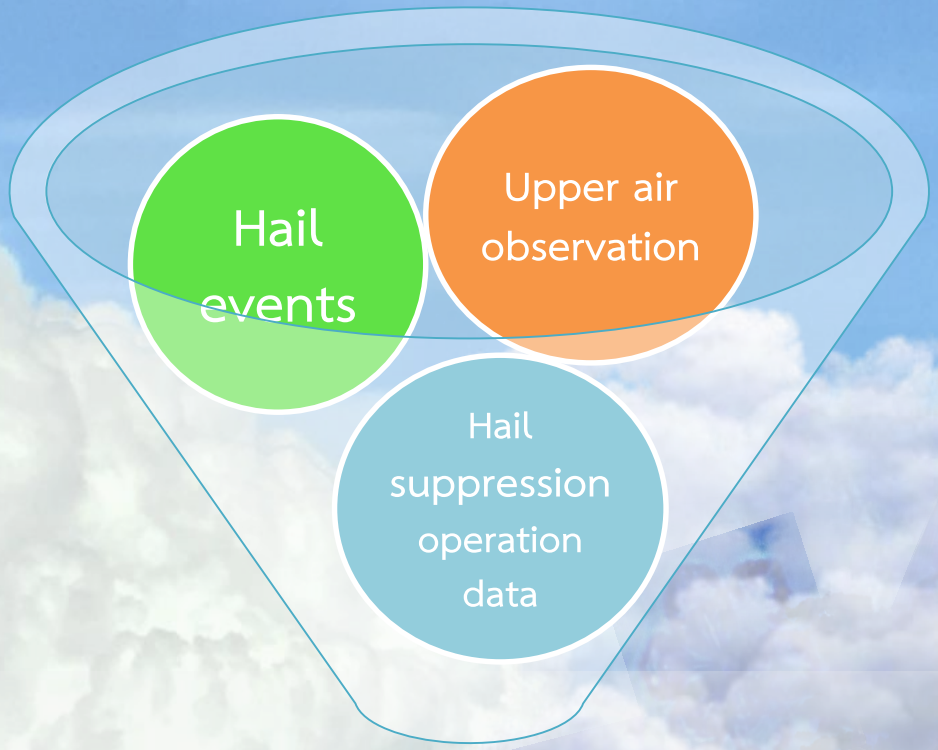


Operation/Warning

Radar Detector

- Maximum > 45 dBz.
- Cloud top > 6 km.
- There was at least 1 group of cloud with Probability of Hail > 0.2
- VIL (kg/m^2) $\geq$ 25 kg/m^2
- Volume > 10 km^3
- Top of Maximum dBz >= 6 km
- The adjacent radar image showed the rapidly arise of cloud group. This is notified from height of the cloud top which is increasing rapidly.

Data Collection



Analysis and Evaluation

Number of Hail Events
February – May 2018

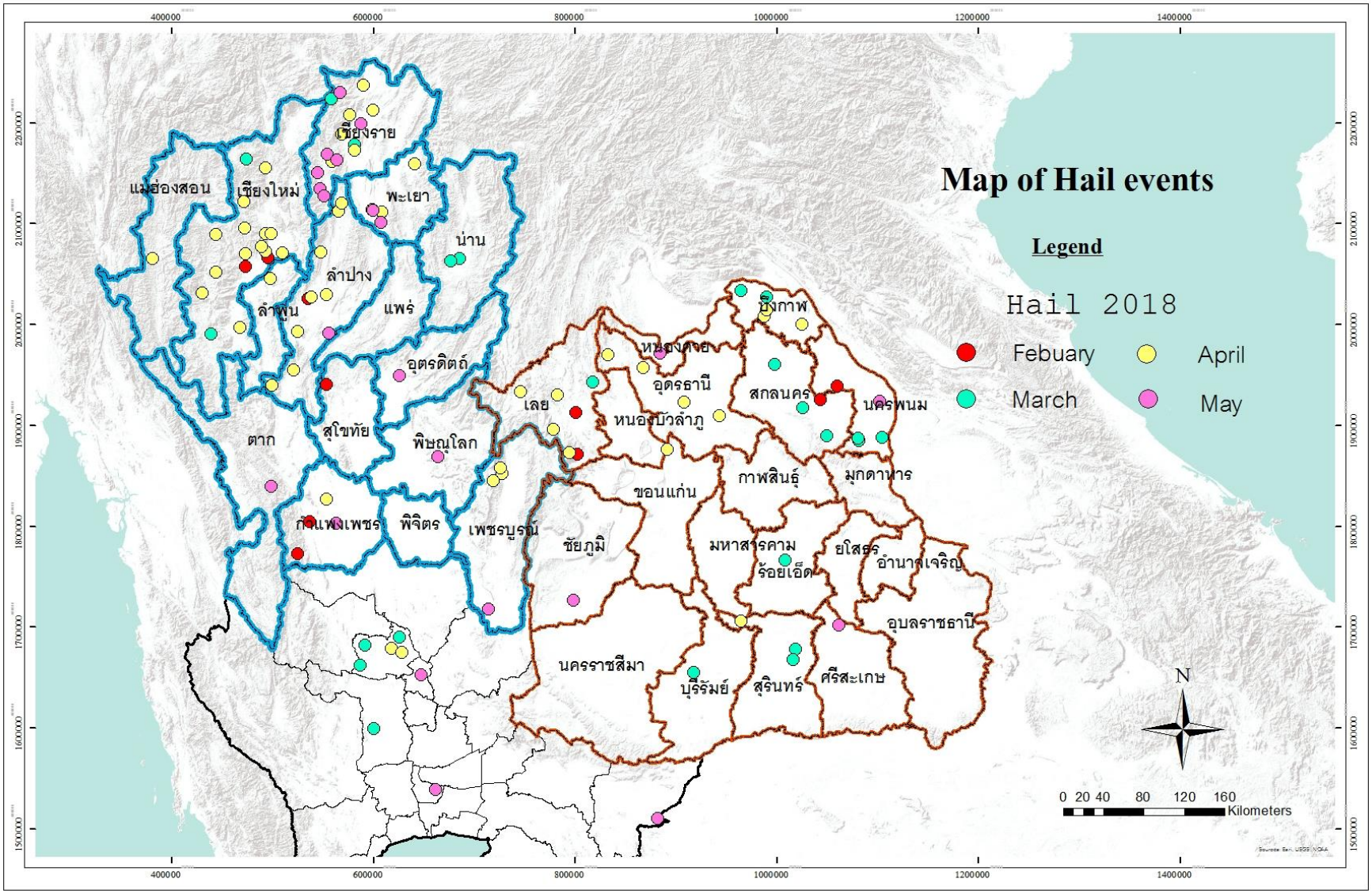
Area	Feb.	Mar.	Apr.	May.	Total
North	7	6	39	17	69
Northeast	4	13	13	5	35
Central	0	3	2	2	7
Total event	11	22	54	24	111
Total day	4	10	13	9	36

Number of Hail Events within operating S-band RADAR*

Area	Feb.	Mar.	Apr.	May.	Total
Omkoi Radar	3	-	-	5	8
Phimai Radar	-	4	5	3	12
Total	3	4	5	8	20

* Counting the number of hail cloud by TITAN program.

Map of Hail Events (2018)



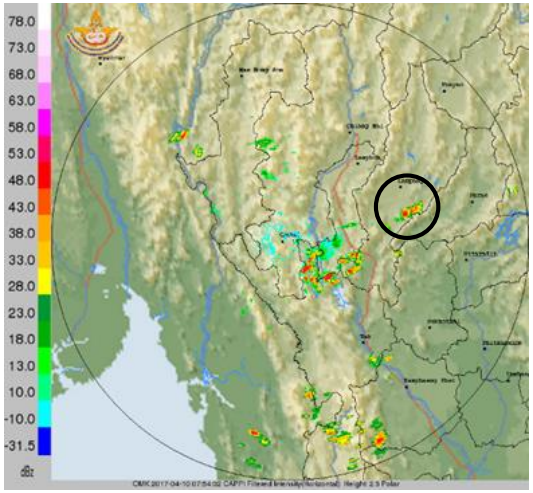
Before Seeding (14:48)

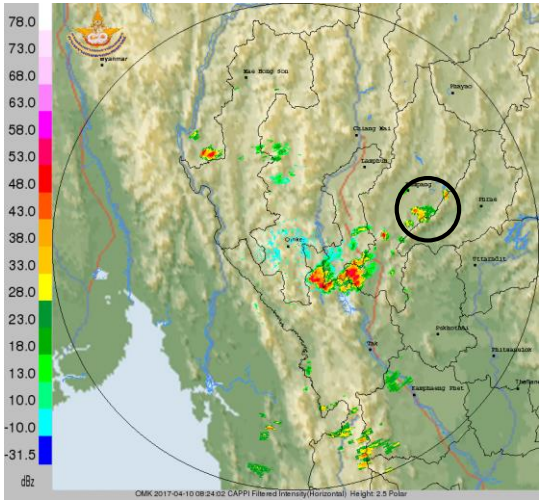
After Seeding (15:15)

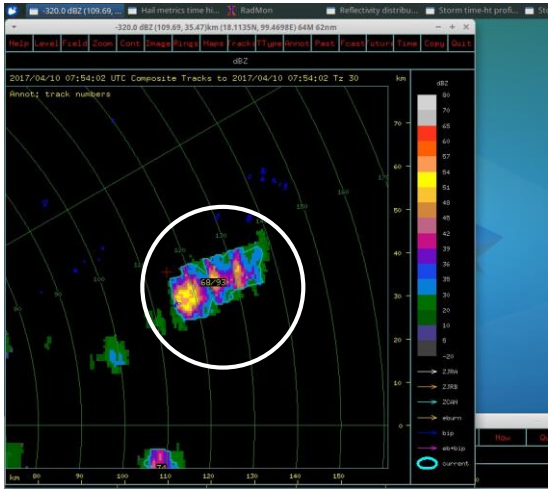
Operation 1 : 10 April 2017

Location : Mae Tha District,
Lampang Province

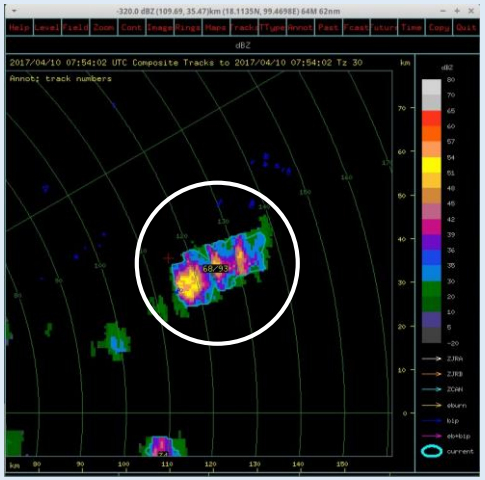
Seeding (14:58)

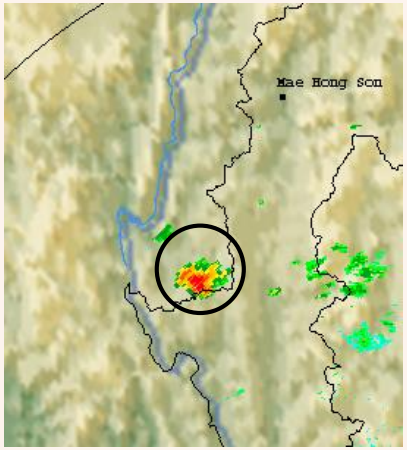


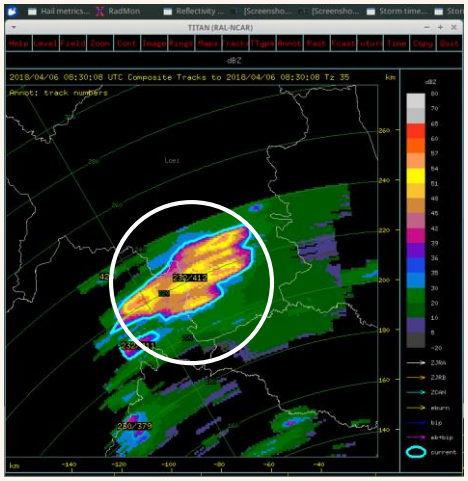


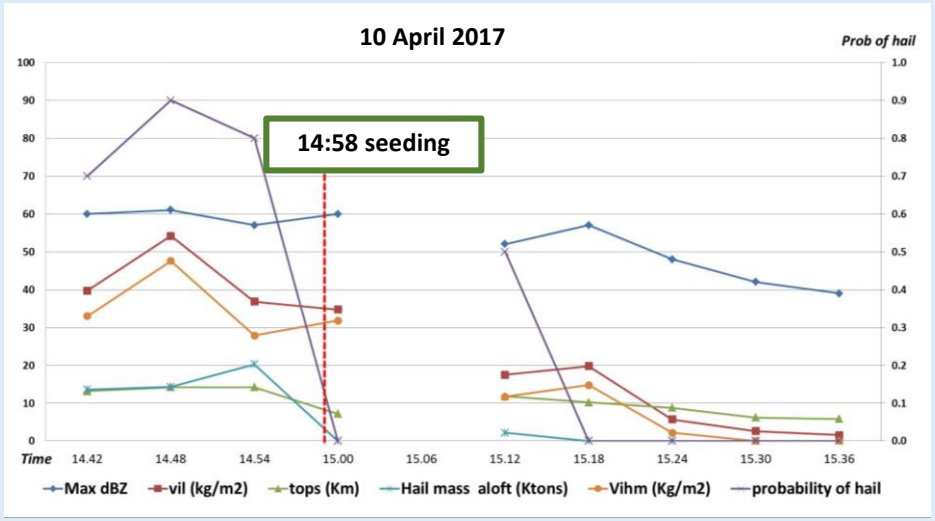


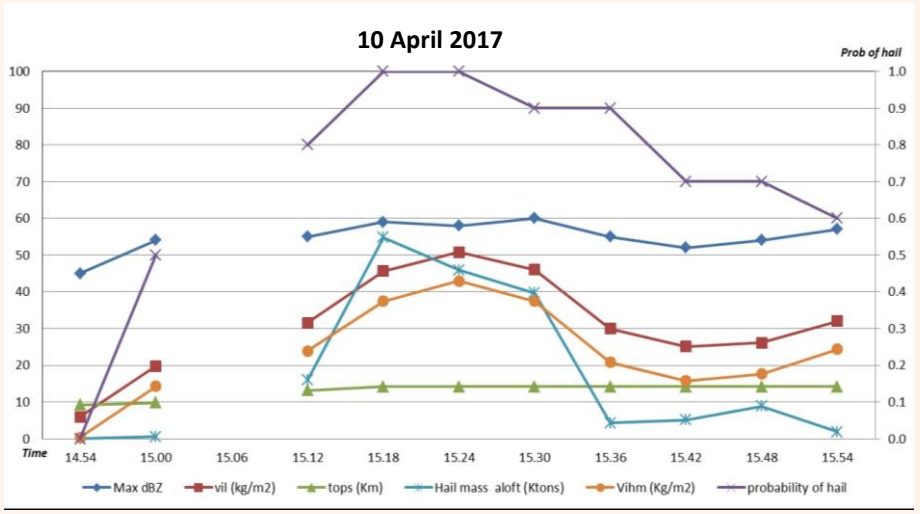
Operation 1 : 10 April 2017







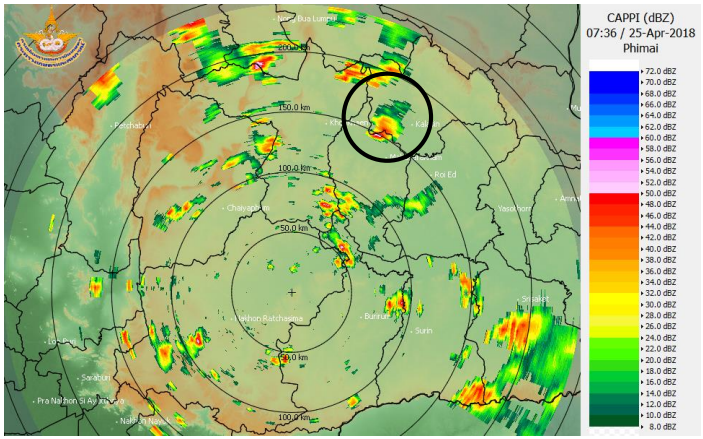




Seed – No hail : Mae Tha, Lampang

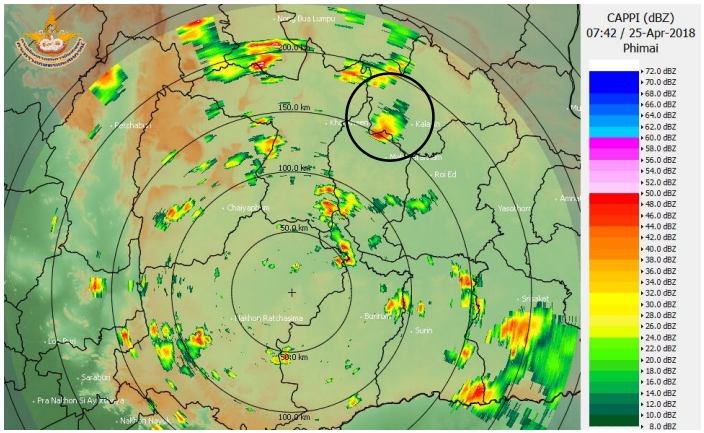
No seed : Mae Sariang, Mae Hong Son

Operation 2 : 25 April 2018



Before Seeding (14:37)

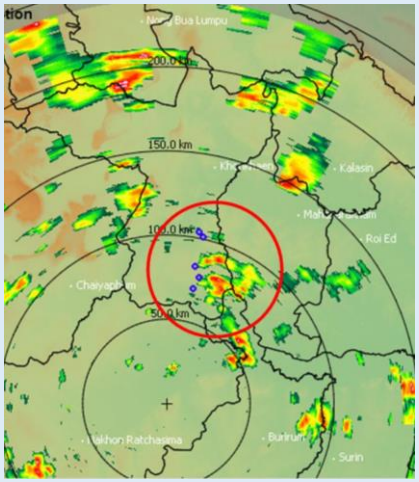
Seeding (14:39)

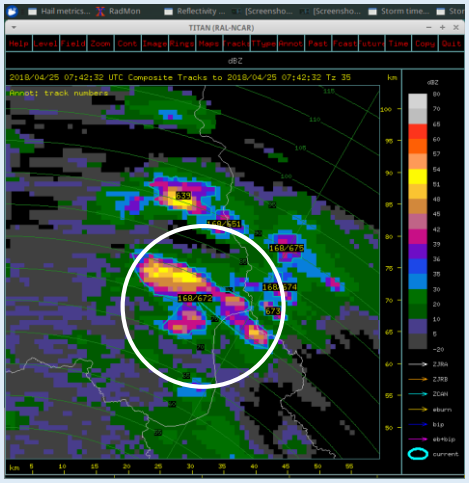


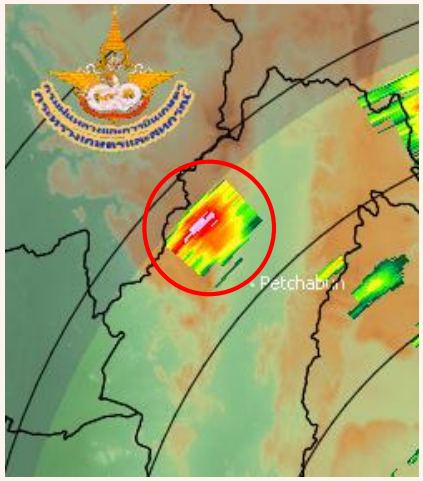
After Seeding (14:43)

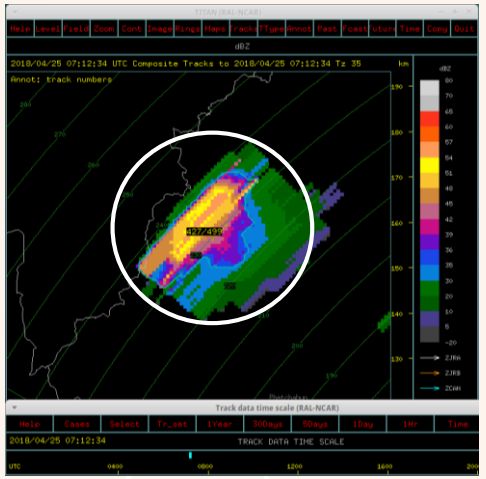
Location : Nong Song Hong District, Khon Khan Province

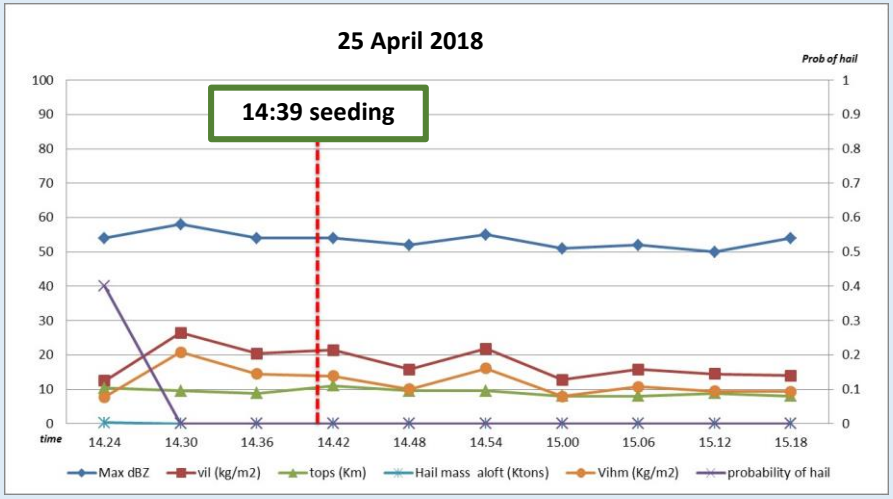
Operation 2 : 25 April 2018

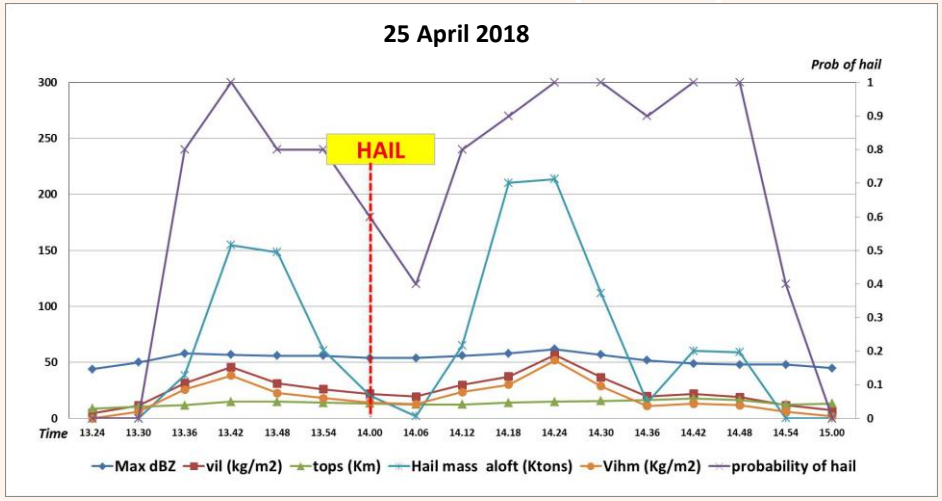












Seed – No hail : Nong Song Hong, Khon Kaen

No seed – Hail : Khao Kho, Patchabun

Preliminary Result

- Hail suppression operation can moderate the harshness of hailstorm since it effectively reduces the hail indicated parameters.
- It is essential to have more study and data gathering about other parameters. (Freezing level, SWI, TTI)
- It should have more study of the likehood cloud in each specific areas such as mountainous area, flat area and affiliating factors which is influent to the area.

THANK YOU FOR YOUR ATTENTION