Research Activities on WxMod in Indonesia

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Badan Pengkajian dan Penerapan Teknologi

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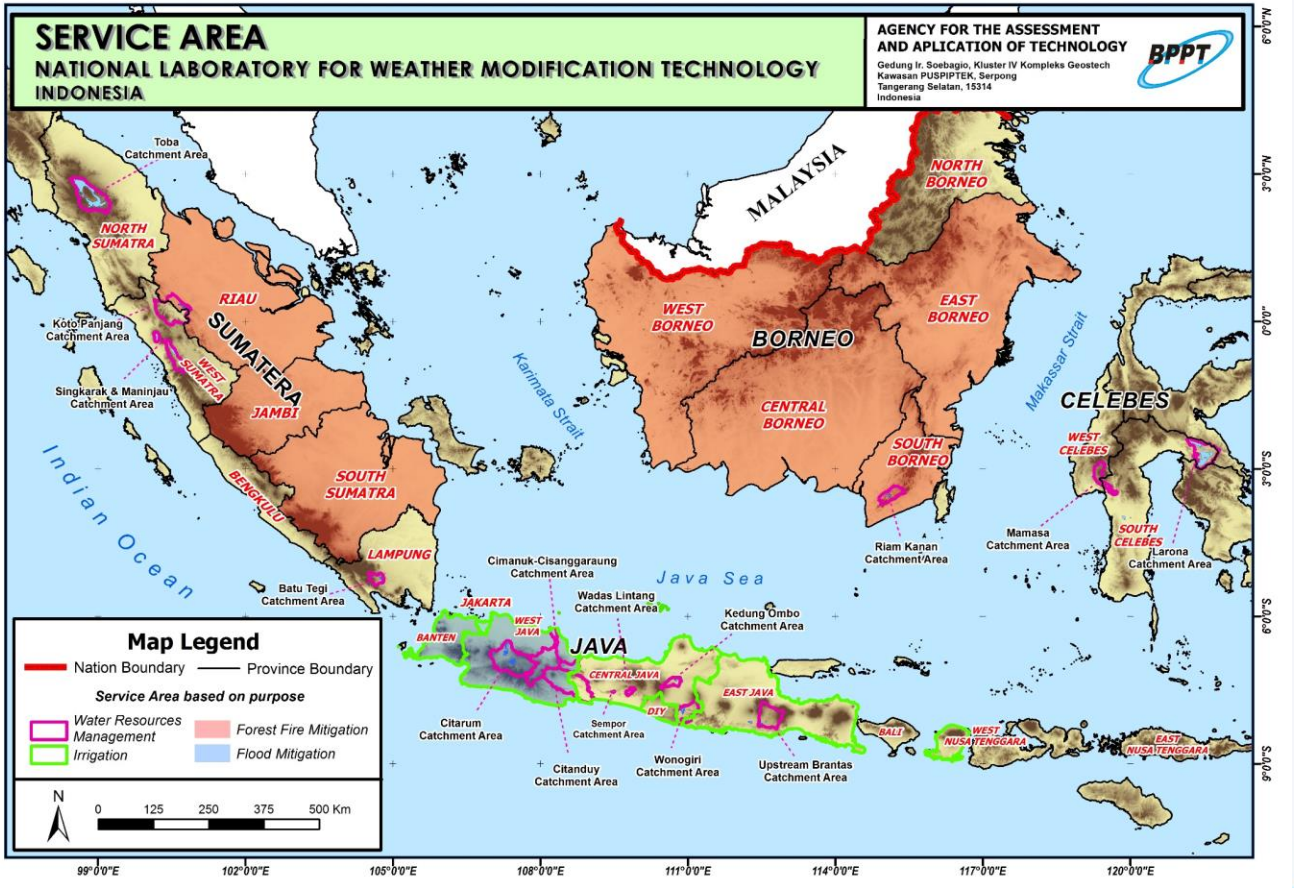
Purposes

Rain Enhancement:

- Hydropower
- Forest fire
- Drought

Rain Reduction:

- Flood disaster
- Open mining
- Infrastructure



Research Areas

Main research:

- Size distribution of seeding agent
- Rocket
- Ejectable tube
- Ground-based
- CCN observation
- Evaluation

Supporting research:

- IOP
- Flood EWS
- Peatland water monitoring

Seeding Agents

- Salt powder, 40-50 micron
- Hygroscopic flare, 0.1 – 3 micron
- AgI flare
- Now developing Salt powder, 2-5 micron

Cloud Seeding Material Development :

A. Main Objectives :

1. To produce a salt-based cloud seeding material prototype with particle sizes between 2-5 um (micrometer).
2. To manufacture a packing system for cloud seeding materials.

B. Ingredients :

1. Bulk-sized NaCl salts.
2. Cab-o-sil (a type of silicon oxide materials) as an anti-coagulant additives to the salt.

C. Equipment & Facilities used to achieve this purpose :

Seeding Material Lab

Jet Mill & Grinding Mill

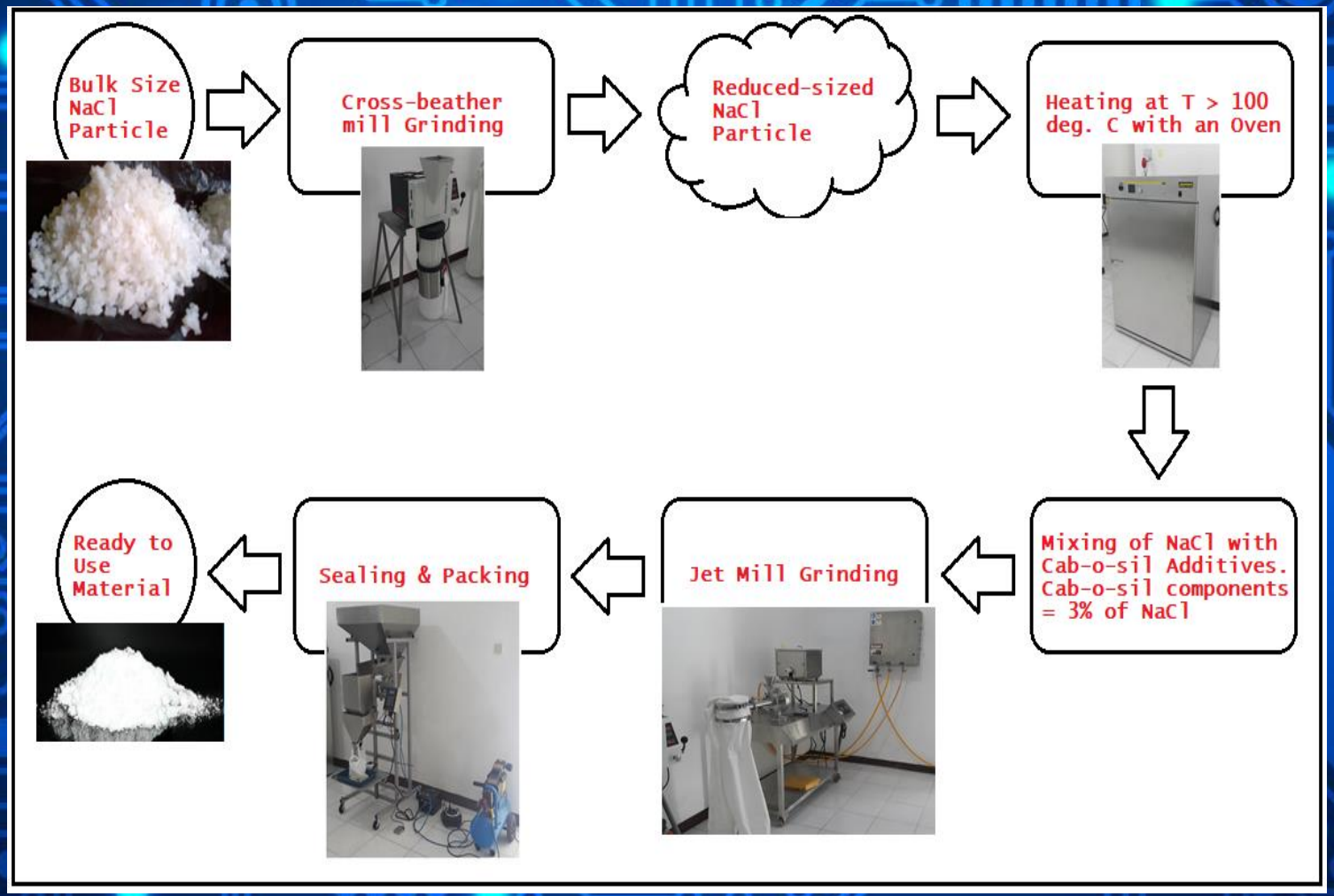
Packing Machine

Oven with Tmax = 300 deg. C

Cloud Seeding Material Development :

Methodology :

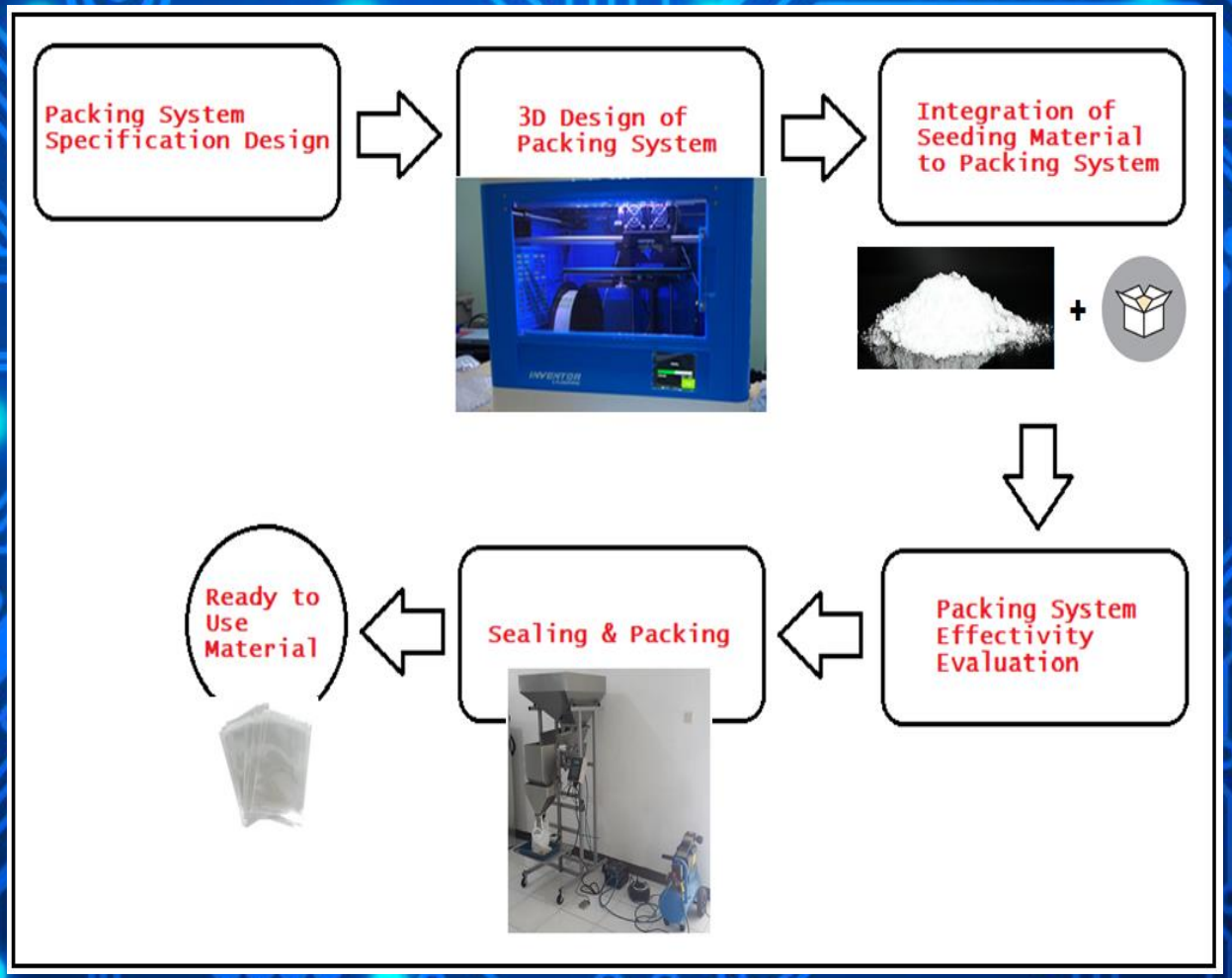
Top-down Mechanical & Heating approach:



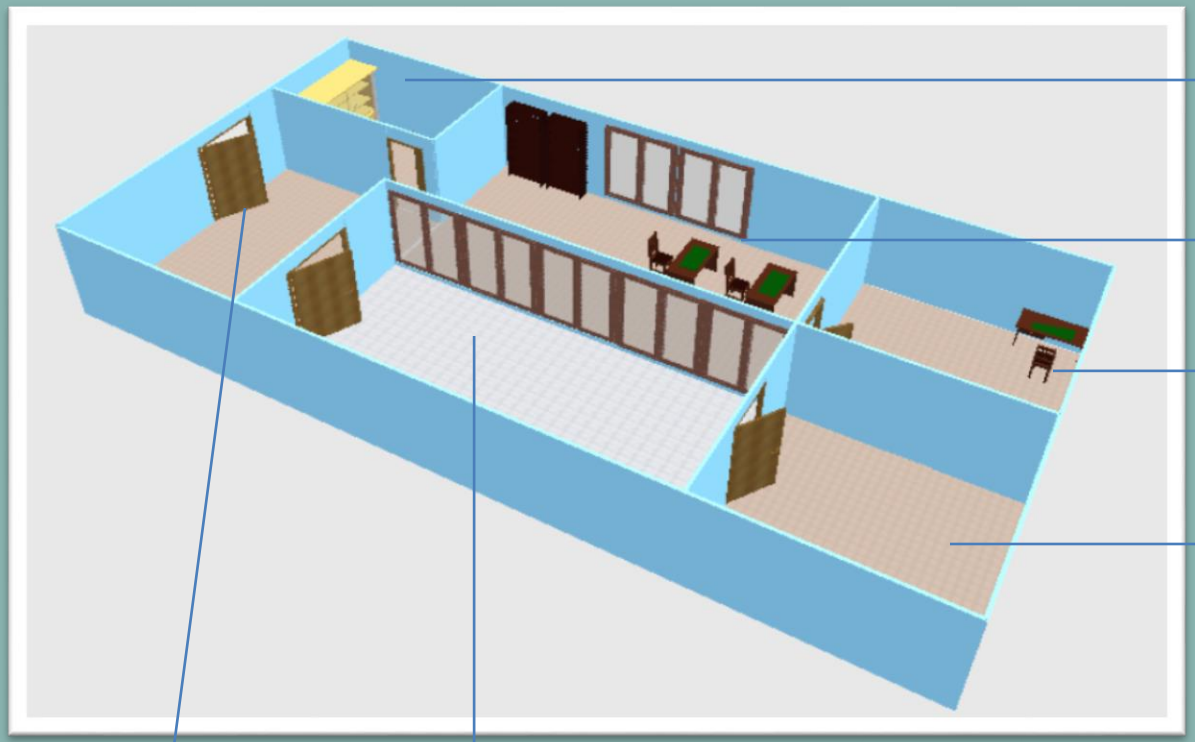
Packing System Development :

Methodology :

Specs Determination, Design, Construction & Integration:



SEEDING MATERIAL LABORATORY



Acid/Chemical Cabinet Chamber

Staff Room

PSA (Particle Size Analyzer) Chamber

2 Micron Seeding Material Storage Room

Jet mill & Packing Room

Preparation Room (Oven , milling, etc)

Seeding Material Laboratory

Cross-Beather/Grinding Mill

Jet Mill & Pressure Control Box

Compressor, Air Tank & Jet Mill Filter

Seeding Material Laboratory

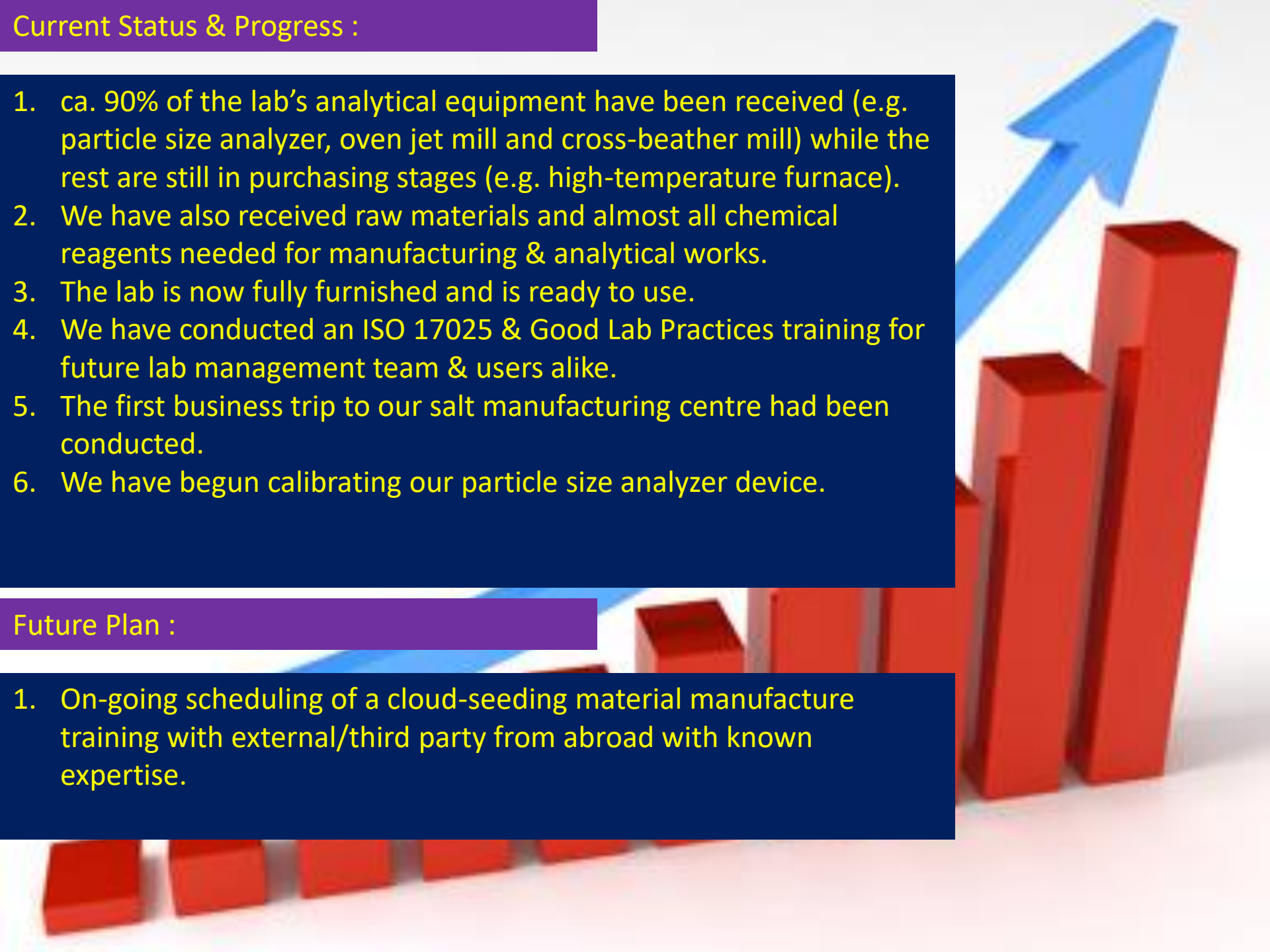
Basic Chemical Test & Analysis Equipment

Electronic Analytical Balance

Automatic Packing Machine

Current Status & Progress :

1. ca. 90% of the lab's analytical equipment have been received (e.g. particle size analyzer, oven jet mill and cross-beather mill) while the rest are still in purchasing stages (e.g. high-temperature furnace).
2. We have also received raw materials and almost all chemical reagents needed for manufacturing & analytical works.
3. The lab is now fully furnished and is ready to use.
4. We have conducted an ISO 17025 & Good Lab Practices training for future lab management team & users alike.
5. The first business trip to our salt manufacturing centre had been conducted.
6. We have begun calibrating our particle size analyzer device.

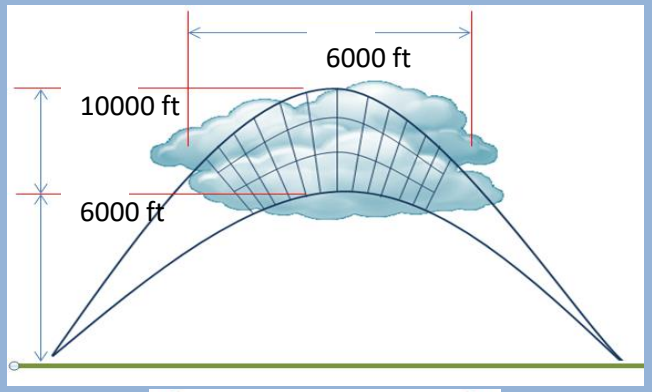


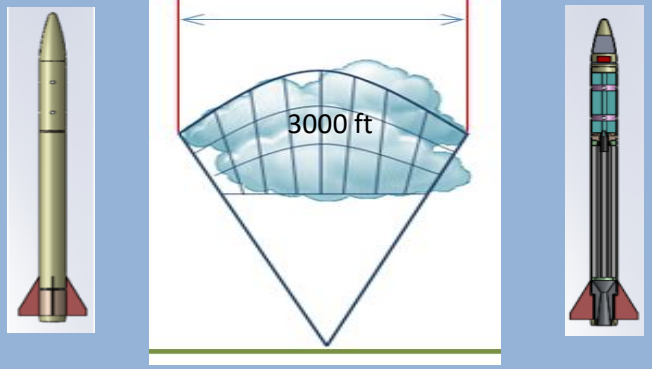
Future Plan :

1. On-going scheduling of a cloud-seeding material manufacture training with external/third party from abroad with known expertise.

WMT Rocket Prototype

WMT Rocket Medium is an alternative medium in delivering seeding material into target clouds with the aid of rocket as a booster materials.





WMT Rocket Operational Tracjectory

WMT Rocket Medium Prototype is a form of research cooperation between NLWMT-BPPT and LAPAN's Rocket Technology Center. It is hoped by 2018 that a WMT Rocket can be built and equipped with a multi-launcher device.

The development of a rocket medium is necessary for a much effective & efficient WMT applications, especially in WMT for rainfall reductions. Rocket medium can be operated in any kinds of locations, day or night and has all weather capabilities, hence increases the quality of rainfall WMT. Rocket medium can serve as an alternative of plane WMT, hence if the merits of this technology is proven, it can be used/proposed as a new medium in WMT operations.

Manufacture of Seeding Material for Rocket Medium via Blasting System

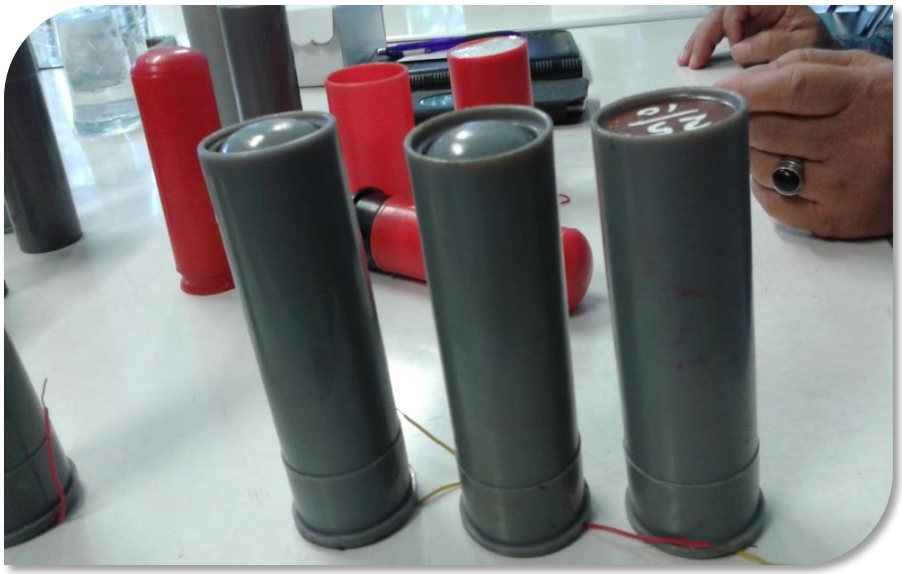
The blasting-based manufactured seeding material needs specially-designed medium so that once it reaches its target it can perfectly dispersed to its surroundings. Hence the rocket medium was specially designed to carry such load within a cloud environment.

Trial of Blasting System-Based Seeding Material

A trial of Blasting System-based seeding material has also been conducted. From the results, ground-tested seeding material had performed satisfactorily.

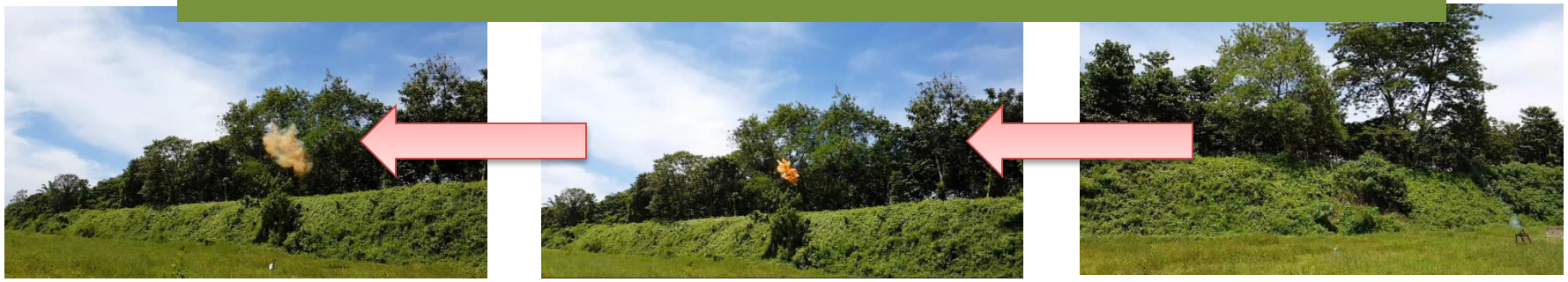
Ejectable Cloud Seeding Material Prototype

Ejectable Cloud Seeding Agent Prototype is a type of seeding material diversification programme



- **ECoSAP is designed to be used in WMT activities with warm cloud targets in mind, with a flying heights of about 12.000-14.000 feet.**
- **It's a PVC-based, tubular form material, with an external diameter of 40 mm and a length of 125 mm. The ECoSAP weight is about 100 gram.**
- **The seeding material used in ECoSAP is an NaCl powder with particle distribution size of 50-60 micron, with material themselves mixed with an anti-coagulant agent.**

Trials of ECoSAP Ejectable System-Based Seeding Material in PT. PINDAD (Turen, Jawa Timur)



For next development, the seeding material used in ECoSAP is a powder salt with a particle distribution size of 2-10 micron.

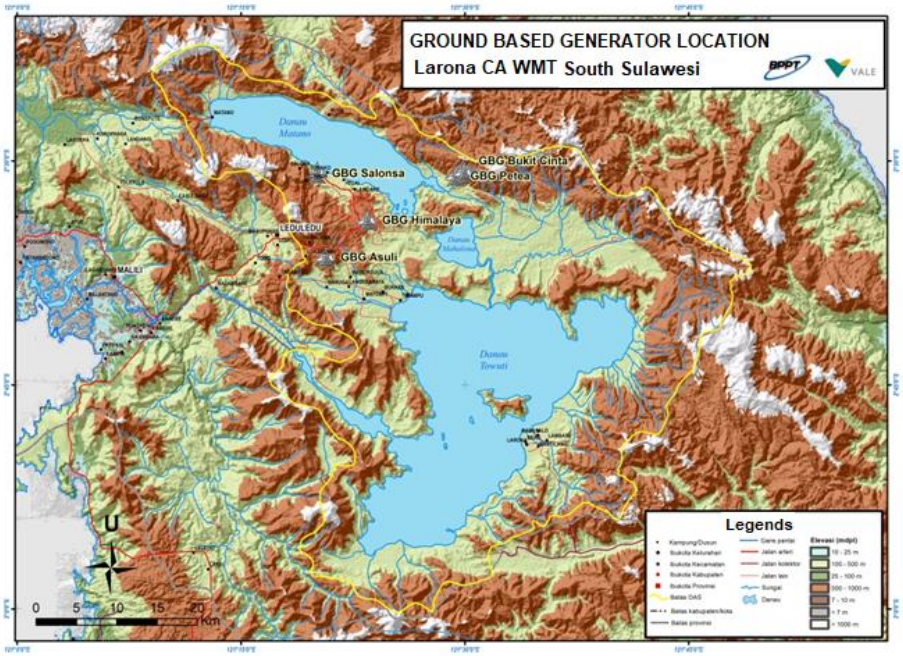
Ground Based Generator (GBG)

The general objecive of cloud seeding for utilities operation water Management is to support the production facilities belonging to PT. Vale Indonesia Tbk in Sorowako, South Sulawesi.

GBG Tower

Height = 50 m

Uses Teleburning System



LOCATION MAP OF GROUND BASED GENERATOR

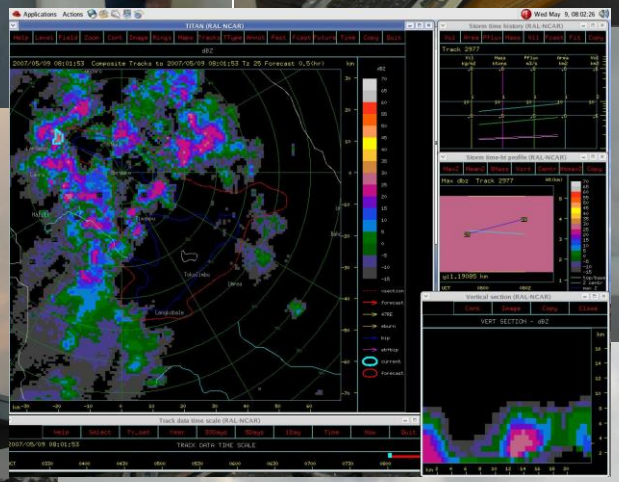
GBG Placement Location:

- Salonsa
- Bukit Cinta
- Himalaya
- Petea
- Asuli

Research Activity at Sorowako

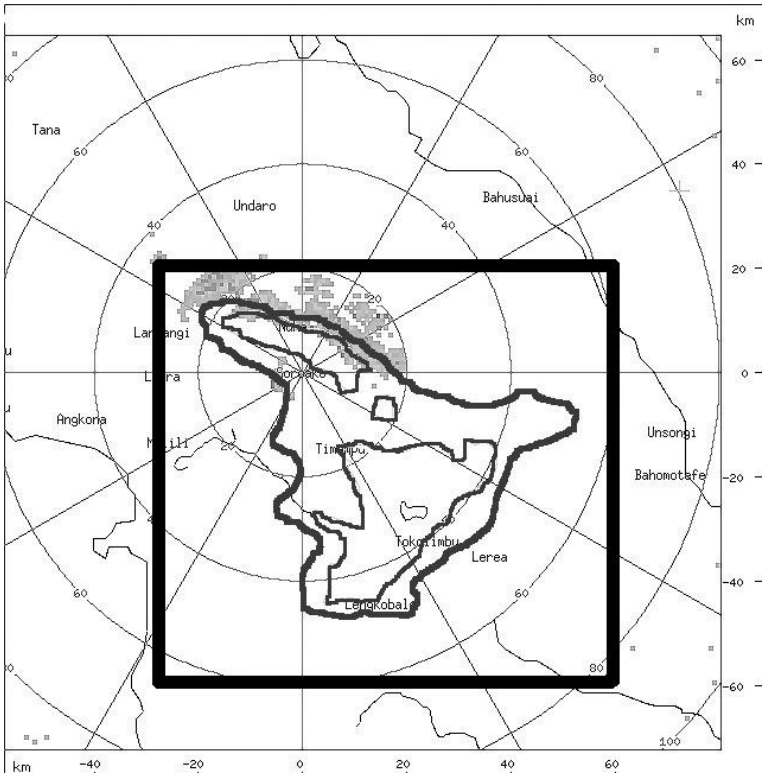
Operations Center

C-band Doppler Radar

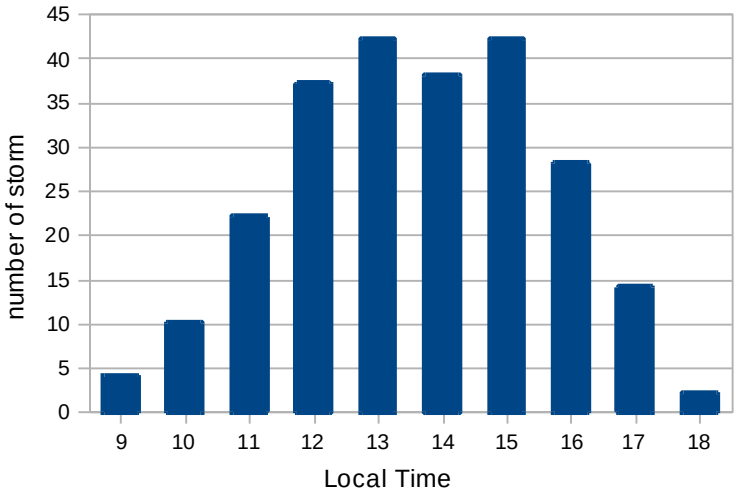


Seeding Aircraft

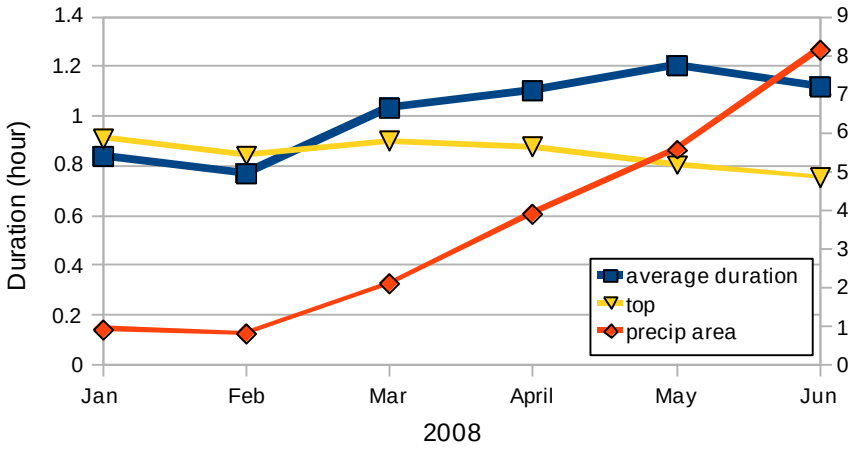
Radar Observation



Diurnal variations of Storm

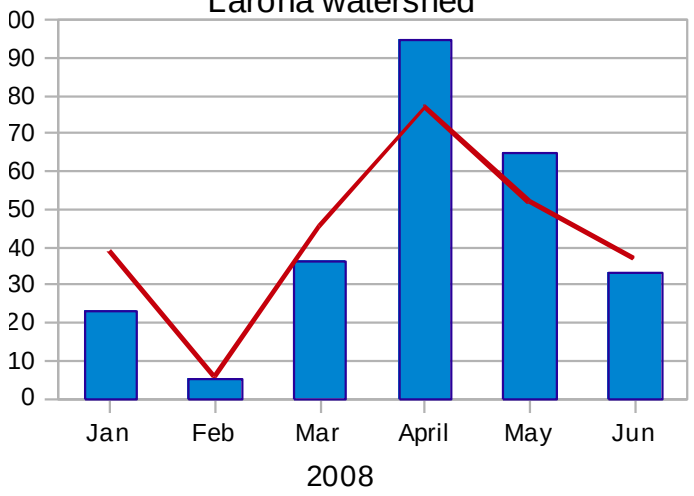


Duration, Precipitation Area, and Top cloud

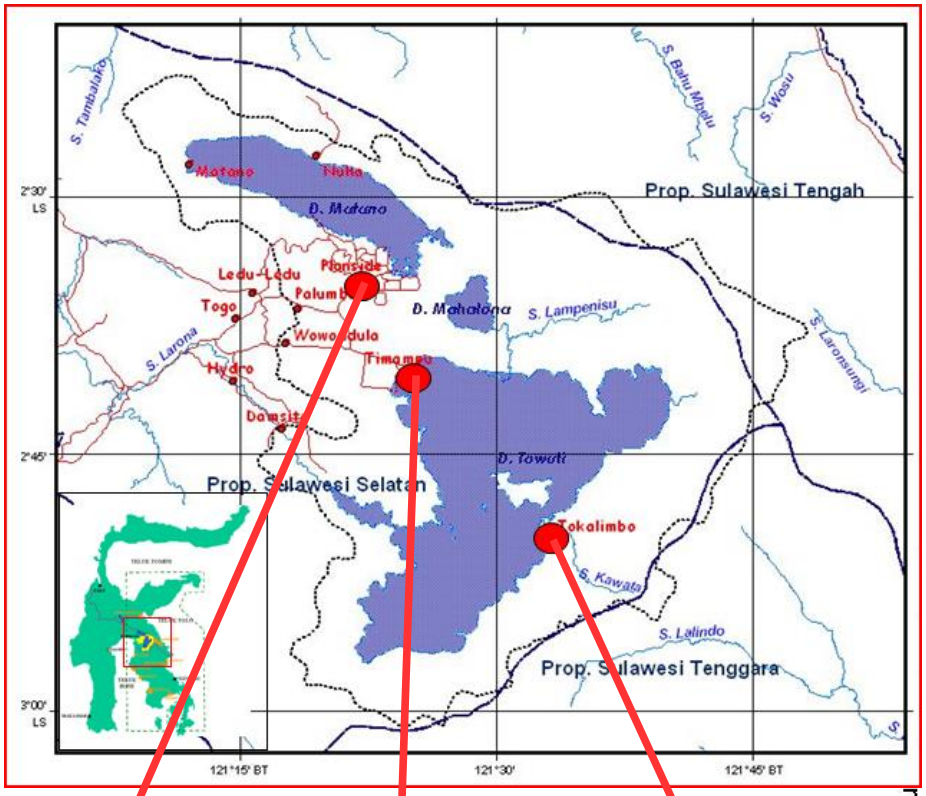


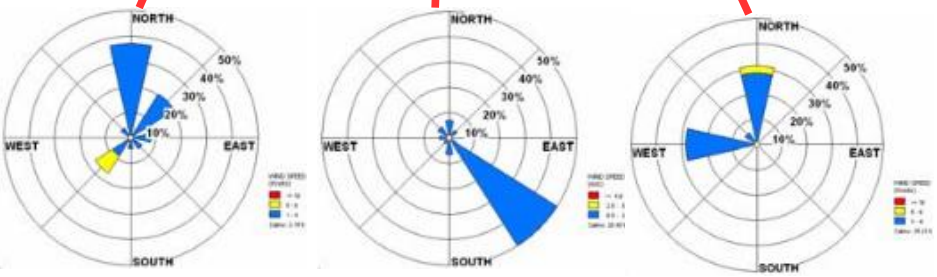
Storm occurrence

Larona watershed

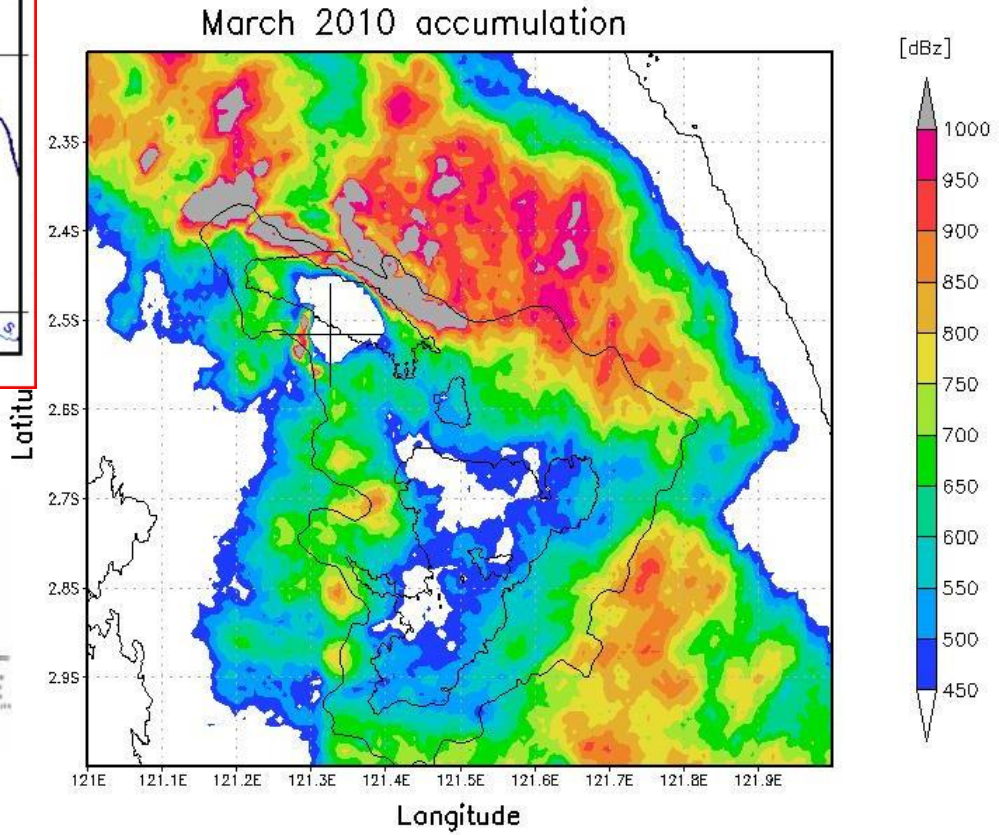


Lake Breeze effects on Convection in Larona Catchment Area, Sulawesi, Indonesia





Wind Rose for Plantsite (left), Timampu (middle) and Tokalimbo (right) on March 2010, 12-17 LT



Accumulation of radar reflectivity for March 2010.

BPPT – WMI – NCAR – INCO 2005

precipitation development studies

PMS 2DC particle imager

Hygroscopic Flares

Data Adquisition system

CCN Counter

Cloud LWC sensor

AgI Flares

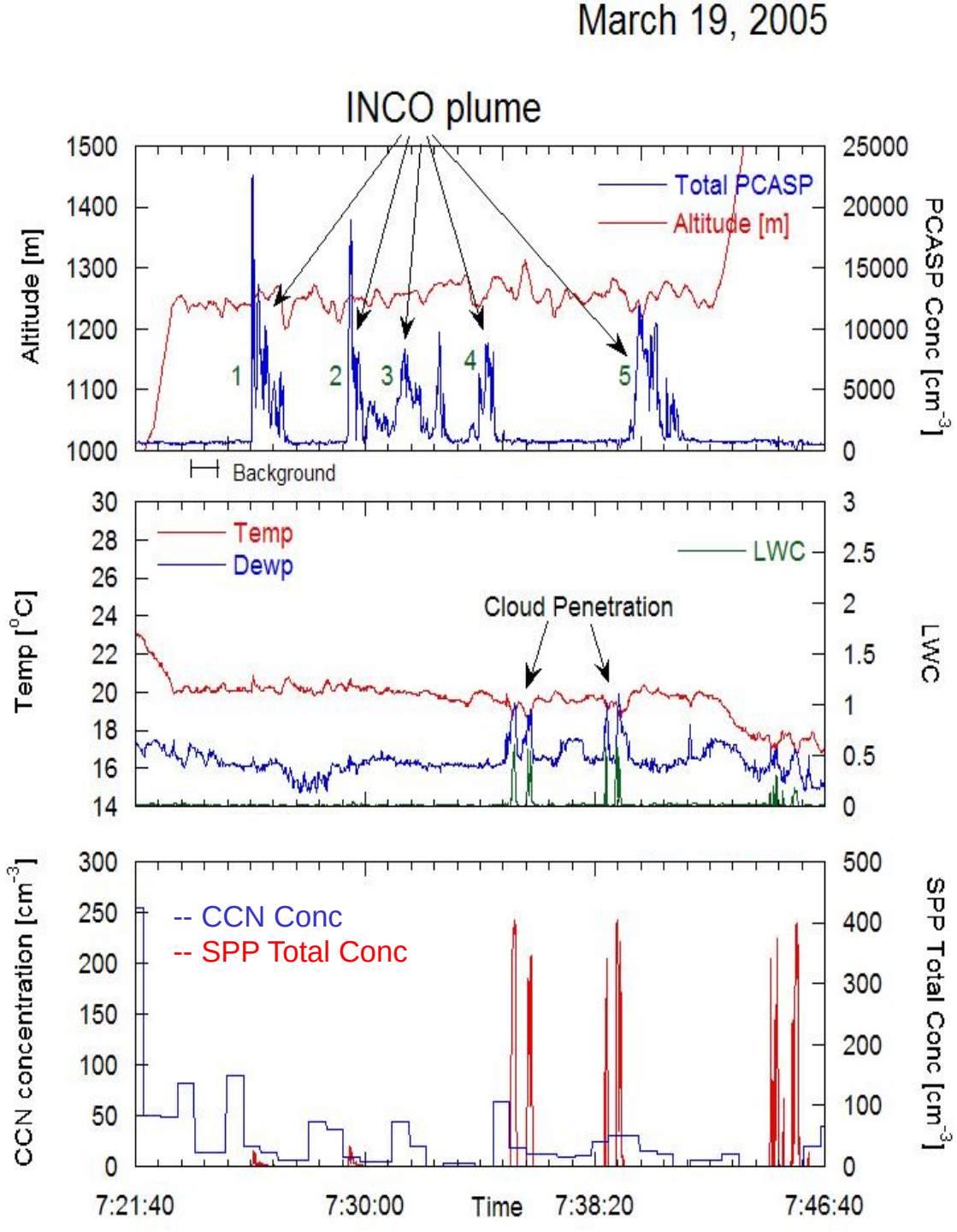
large aerosol and cloud droplets

PMS FSSP counter

aerosol characterization (concentrations and sizes) for aerosol-cloud interactions

PMS PCASP Aerosol Counter

AgI Ejectables



Time-series plots of the PCASP aerosol concentrations (cm^{-3}), altitude (m),

temperature (°C), dewpoint (°C), liquid water content ($g\ m^{-3}$)

CCN (cm^{-3}) and cloud droplet concentrations (cm^{-3})

Feasibility Study for Augmentation of Rain in Sulawesi,
Final Report 2005 WMI RPRT_INCO

Properties of cloud and atmosphere over Sorowako South Sulawesi

- Aerosol, CCN and cloud droplet concentrations are typical of clean maritime atmospheres

- At low CCN background concentrations, the cloud properties are more sensitive to a change in N_{CCN}

- Emissions from anthropogenic sources are very important to study.

STATISTICAL EVALUATION FOR WEATHER MODIFICATION TECHNOLOGY IN INDONESIA

Badan Pengkajian dan Penerapan Teknologi

INTRODUCTION

- Agency for the Assessment and Application of Technology, Indonesia has conducted the Weather Modification Technology since 1967 to enhance rainfall.

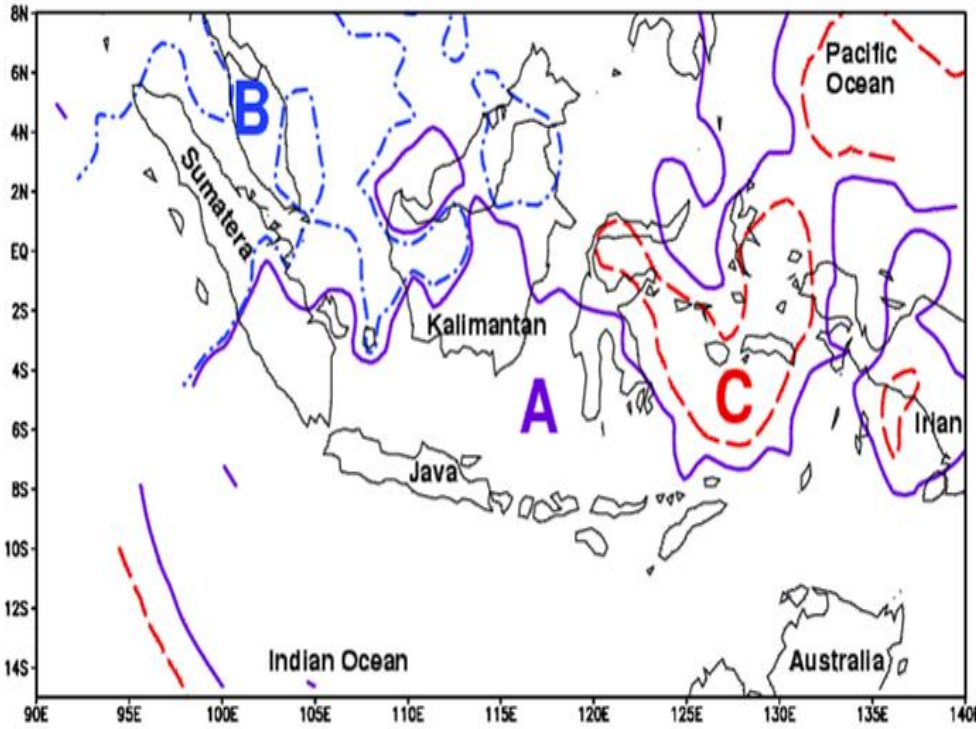
- Cloud activity over the Indonesian Maritime Continent (IMC) shows variations time scales : inter-annual and seasonal variations, intra-seasonal variations, and variations with periods of less than several ten days. Other than cumulus activity with a period of longer than several days, diurnal cycle of cumulus convection induced by local circulation (land-sea and/or mountain-valley breeze circulation) is also prominent because the IMC is composed of many island and the surrounding sea.

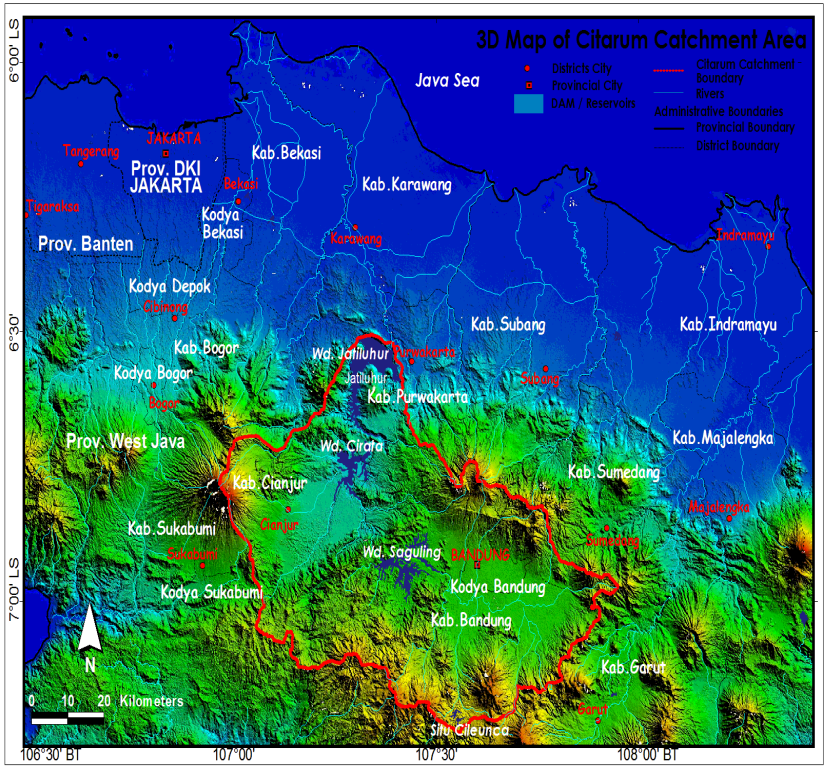
- These variations cause large deviation on average of climatologically rainfall. Therefore, it is very difficult to evaluate the enhancement.

- In this presentation, evaluation design for weather modification technology on West Java, Indonesia is discussed.

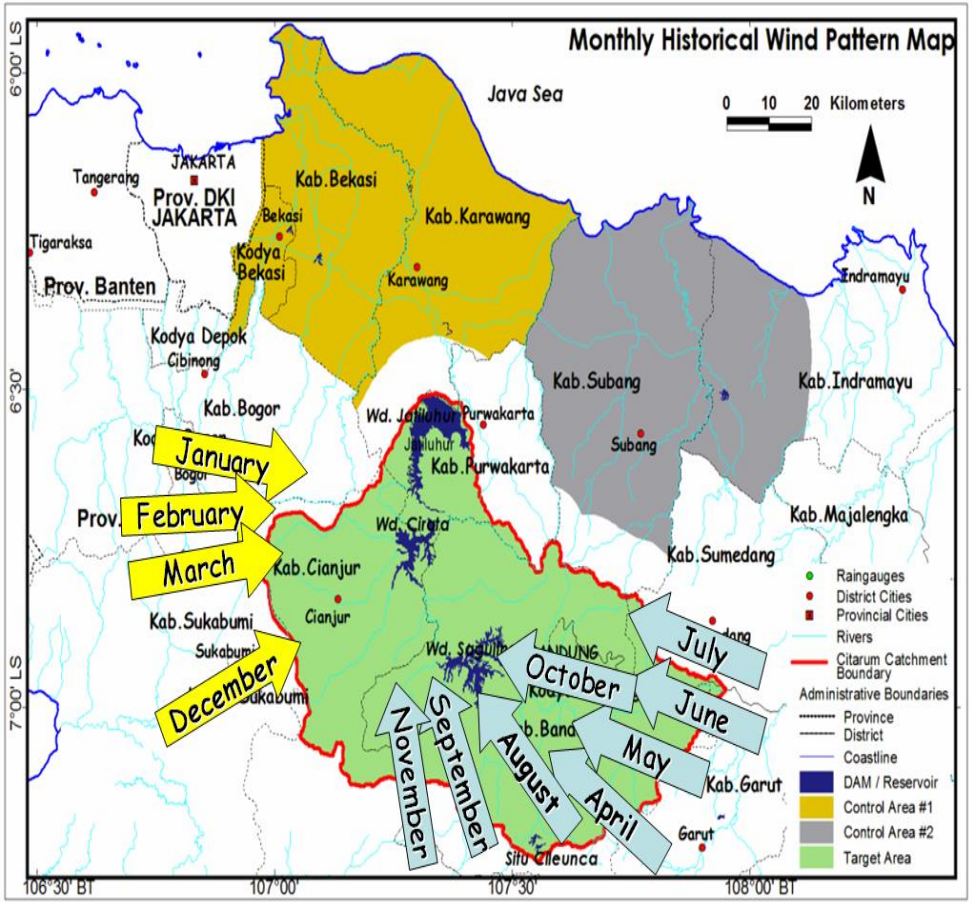
METHOD

For the first, control areas are tried to be defined. Variability on temporal and spatial scale causes the difficulty to choose control area . Since this difficulty, control area may be different along year.



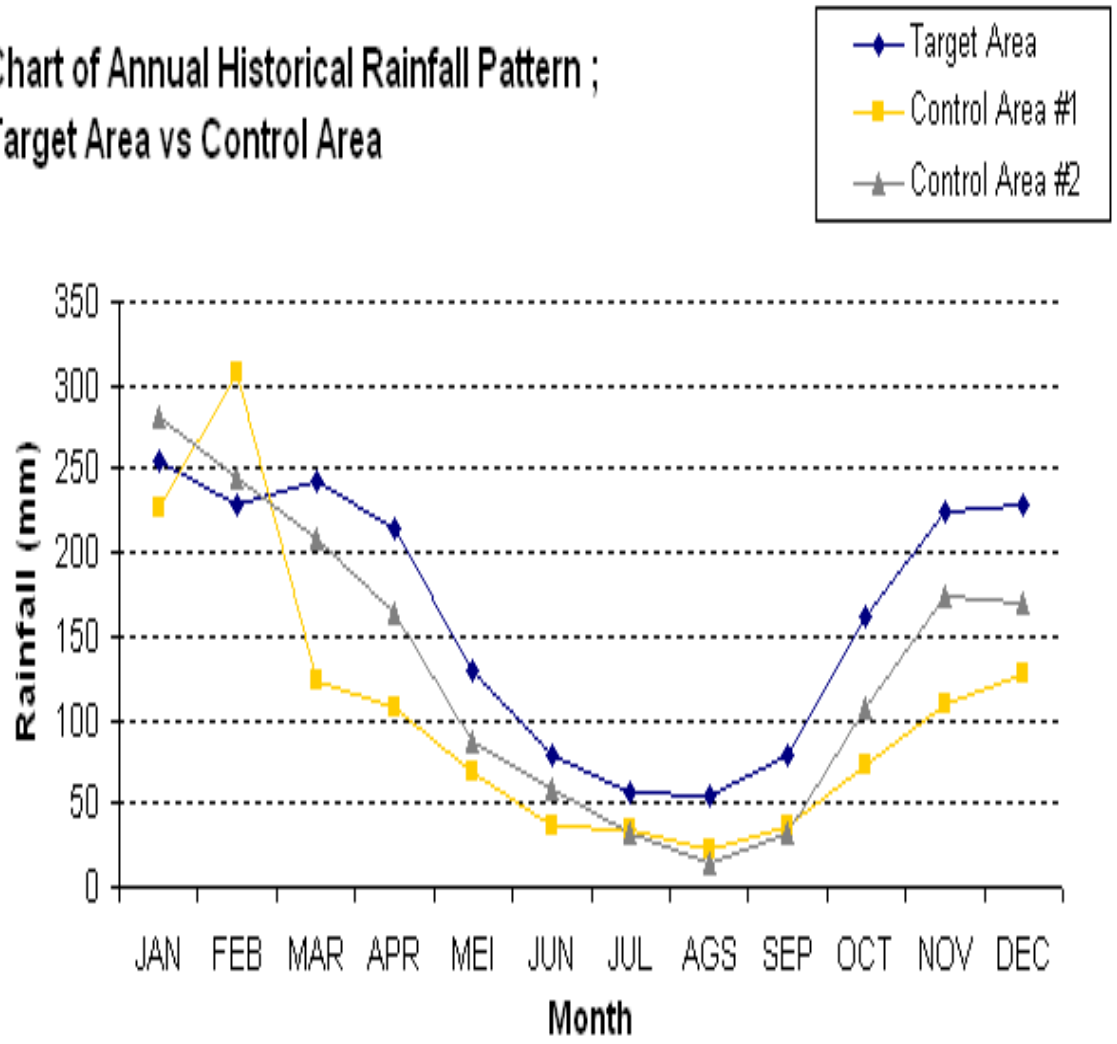


TARGET AND CONTROL AREA

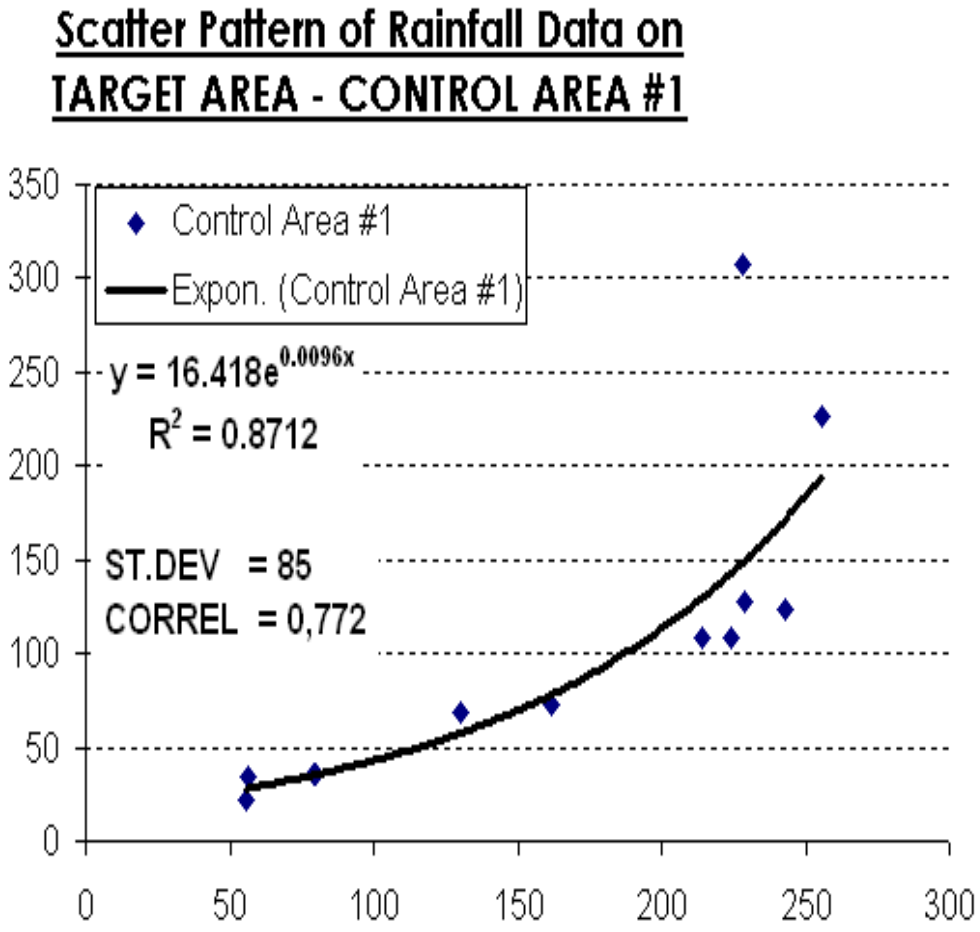


1. Based on wind pattern historically on target area, the area on north side of Citarum cathcment (Karawang and Bekasi) could be defined as control area for periode December – March.
2. Based on wind pattern historically on target area, the area on north side of Citarum cathcment (Karawang and Bekasi) could be defined as control area for periode December – March.
3. Analysis rainfall data historical from 1986-2009 shows that the annual rainfall pattern between Citarum catchment and both of control areas has strong correlation ; 0,772 for

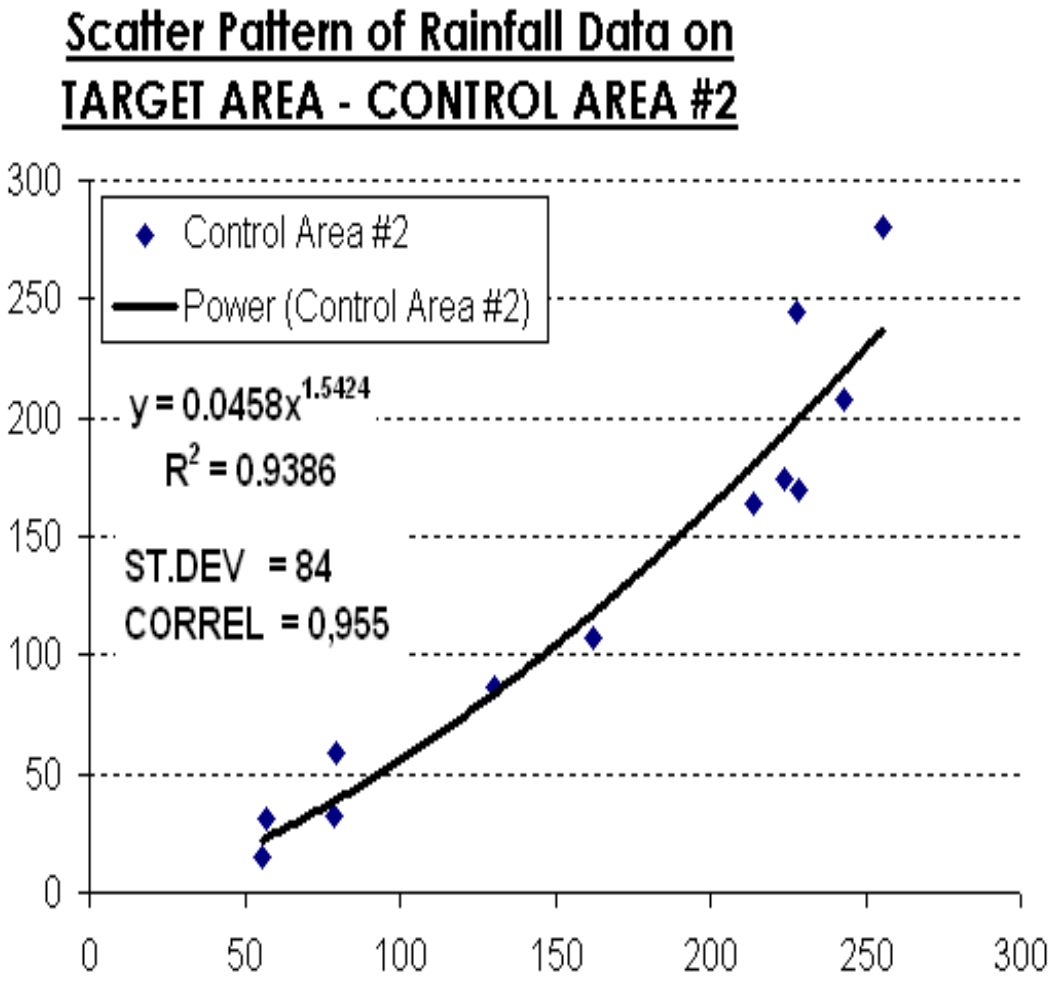
TARGET AND CONTROL AREA (CONT)



TARGET AND CONTROL AREA (CONT)



TARGET AND CONTROL AREA (CONT)



EVALUATION OF INCREASING RAINFALL FROM CLOUD SEEDING ACTIVITY

The Increasing of rainfall as the result from cloud seeding activity can be calculated by the statistical analysis approach. There are 3 methods can be used for this aim :

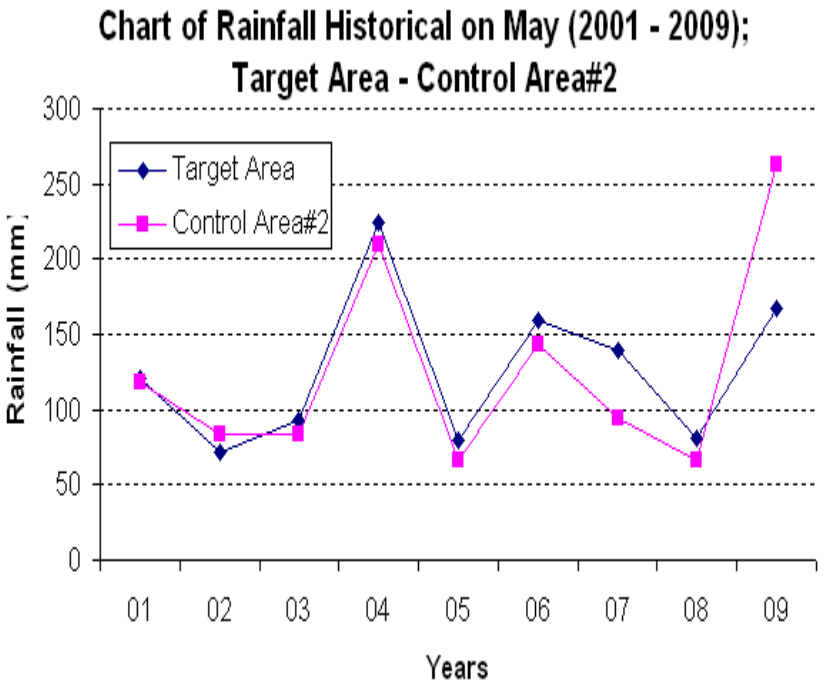
1. Target Only Method

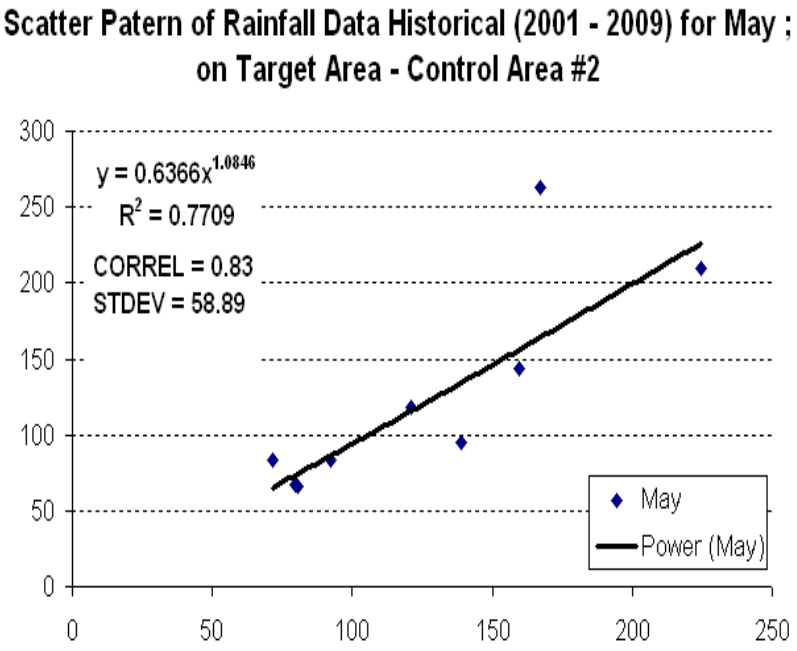
2. Target Control Method

3. Double Ratio Method

EVALUATION OF INCREASING RAINFALL FROM CLOUD SEEDING ACTIVITY (CONT)

For example, the rainfall data from cloud seeding activity at Citarum Catchment Area that has been done on 4-25 May 2007 will try to evaluate to know the increasing rainfall that happen. This chart below shows the rainfall pattern historicallly (from 2001-2009) on May





EVALUATION OF INCREASING RAINFALL FROM CLOUD SEEDING ACTIVITY (CONT)

1. <u>Target Only Method</u>

This method using mean rainfall data historical as the base information for comparation. The effect of cloud seeding and the increasing of rainfall can be calculated by compare the rainfall on target area during cloud seeding period with historical data at the same time for this area. The increasing of rainfall on [illegible]lated by this equation :

$$R = \frac{CH_a - Ch_s}{Ch_s} x100\%$$

Where,

R = the increase of rainfall (%)

CHa = rainfall actual on target area (mm)

CHs = mean historical rainfall on target area (mm)

EVALUATION OF INCREASING RAINFALL FROM CLOUD SEEDING ACTIVITY (CONT)

By this method, the result of increasing rainfall has range from **11,9 %** to **82,9 %** ; as can b

Historical Rainfall for May on Target Area and Control Area

NON STRATIFIED				STRATIFIED			
TARGET		CONTROL		TARGET		CONTROL	
Years	Rainfall (mm)	Years	Rainfall (mm)	Years	Rainfall (mm)	Years	Rainfall (mm)
1986	113,8	1990	143,3	1987	114,8	1990	143,3
1987	114,8	1991	122,0	1988	173,5	1991	122,0
1988	173,5	1992	28,0	1989	204,3	1992	28,0
1989	204,3	1993	31,8	1990	163,7	1996	106,3
1990	163,7	1994	0,0	1991	36,8	1997	19,4
1991	36,8	1995	74,2	1992	104,9	1998	74,7
1992	104,9	1996	106,3	1993	66,3	1999	63,5
1993	66,3	1997	19,4	1994	69,8	2000	76,6
1994	69,8	1998	74,7	1995	96,9	2001	118,5
1995	96,9	1999	63,5	1996	90,9	2002	83,8
1996	90,9	2000	76,6	1997	123,7	2003	83,3
1997	123,7	2001	118,5	1998	162,9	2004	209,9
1998	162,9	2002	83,8	1999	178,4	2006	144,0
1999	178,4	2003	83,3	2000	137,2	2008	66,4
2000	137,2	2004	209,9	2001	121,1	2009	263,3
2001	121,1	2005	66,8	2002	71,4		
2002	71,4	2006	144,0	2003	92,4		
2003	92,4	2007	94,7	2004	224,6		
2004	224,6	2008	66,4	2006	159,7		
2005	79,6	2009	263,3	2007	138,7		
2006	159,7			2008	80,6		
2007	138,7			2009	167,2		
2008	80,6						
2009	167,2						
Mean	***123,9***		***93,5***		***126,4***		***106,9***
STD.DEV	***47,8***		***62,8***		***48,9***		***64,7***

Calculating Rainfall Increase on Target Area by Target Only Method (Mei 2007)

	Normal (1986 - 2009)			Stratified		
	X	X + SD	X - SD	X	X + SD	X - SD
Rainfall mean historical (mm)	123,9	171,6	76,1	126,4	175,3	77,4
Rainfall actual (mm)	138,7					
Rainfall increase (%)	**11,9**	**-19,2**	**82,2**	**9,8**	**-20,9**	**79,1**

EVALUATION OF INCREASING RAINFALL FROM CLOUD SEEDING ACTIVITY (CONT)

2. Target Control Method

Statistical analysis by this method need an control area for comparation. The increasing rainfall on target area during cloud seeding period can be estimated from regression equation using rainfall data historical from control area as free variable and rainfall data historical from target area for the same interval period. The rainfall data actual that was measured and has assumption that was impact by cloud seeding activity. The increasing of rainfall on this method calculated by this equation :

$$R = \frac{CH_a - Ch_s}{Ch_s} x100\,\%$$

R = [(138,7 – 97,975) / 97,975] x 100 %

= **41,56 %**

Where,

R = the increase of rainfall (%)

CHa = rainfall actual on target area (138,7 mm)

CHs = estimation of rainfall on target area, that was estimated from regression equation ;

y = 0,0065x2 - 1,0527x + 118,94 (= 97,975 mm)

By this method, the result of increasing rainfall is **41,56 %**

EVALUATION OF INCREASING RAINFALL FROM CLOUD SEEDING ACTIVITY (CONT)

3. Double Ratio Method

The natural rainfall has strong variation (temporally and spatially), and to minimize the effect of this variation, We can used statistical analysis with Double Ratio Method. This analysis comparing between the ratio amount of rainfall on target area toward control area during cloud seeding period by the same ratio during no cloud seeding activities period. Approaching of historical data can be done by two way ; first, by using normaly historical data (in these example, using data historical from 1986 – 2009), and second, using data historical stratified

The calculation by double ratio method using these equation following :

$$R = (T / C)a / (T/C)us$$

Where,

R = " Double Ratio" value

(T/C)a = ratio between actually rainfall on target area during cloud seeding period,and rainfall on control area at the same time

(T/C)us = ratio between rainfall on target and control area during period no cloud seeding activities.

The increasing of rainfall that was assumed get impact from cloud seeding activity can be calculated by this equation :

$$R\ \% = (DR - 1) \times 100\ \%$$

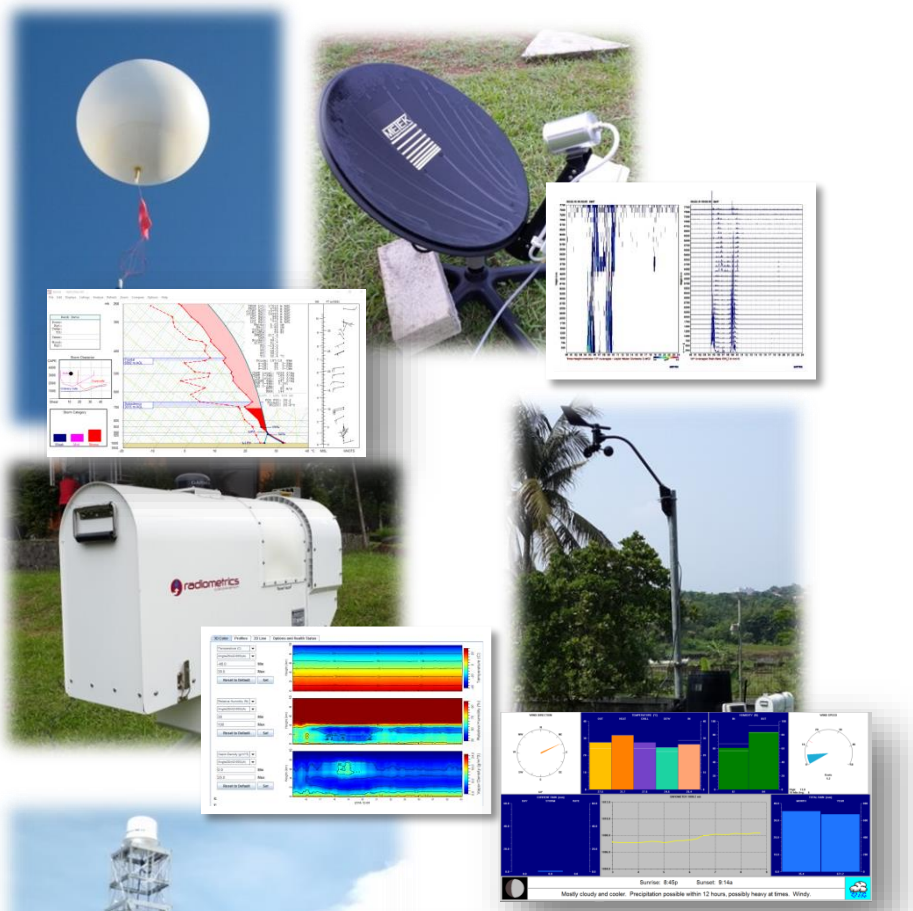
EVALUATION OF INCREASING RAINFALL FROM CLOUD SEEDING ACTIVITY (CONT)

By this method, the result of increasing rainfall has range from **10,5 %** to **43,3 %** ; as can be seen on the table below.

Calculating Rainfall Increase on Target Area by Double Ratio Method (Mei 2007)

		Normal (1986 - 2009)			Stratified		
		X	X + SD	X - SD	X	X + SD	X - SD
Rainfall mean historical (mm)	Target	123,9	171,6	76,1	126,4	175,3	77,4
	Control	93,5	156,3	30,7	106,9	171,6	42,2
Rainfall actual (mm)	Target	138,7					
	Control	94,7					
Rainfall increase (%)		**10,5**	**33,4**	**-40,9**	**23,9**	**43,3**	**-20,2**

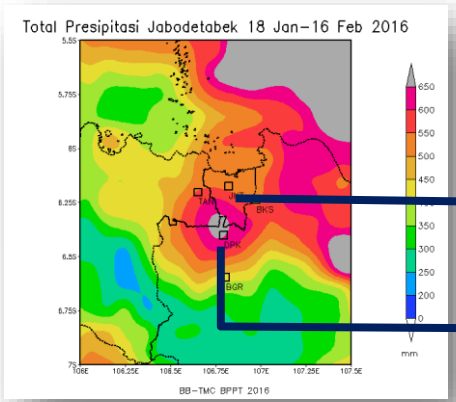
INTENSIVE OBSERVATION PERIOD



Intensive Observation Period (IOP) was a form of cooperation between NLWMT-BPPT & The Indonesian Agency of Meteorology, Climatology and Geophysics (BMKG) which was held for 30 days from 18 January-16 February 2016. The objective of this partnership was to further understand detailed atmospheric conditions during the occurrence of high rainfall event that causes floods in Jakarta.

The observation was centered on 2 locations, i.e. Puspiptek Serpong Area and BMKG's Climatology Station in Dramaga Bogor with the following instruments:

- Mobile Radar
- Micro Rain Radar
- Automatic Weather Station
- Radiosonde
- Radiometer
- Drone



The rainfall intensity in the Jakarta Special Region and Bekas was = 500-600 mm with higher rainfall occuring in its southern and eastern part.

The highest rainfall occurs in Depok and South Tangerang with intensities reaching up to more than 650 mm.

FOREST FIRES IOP

LAND OBSERVATION

WEATHER OBSERVATION

Radiometer Installations

Acquisition of Weather data by using radiometer instrument which will also be taken to Palembang

Measured Parameter from radiometer :

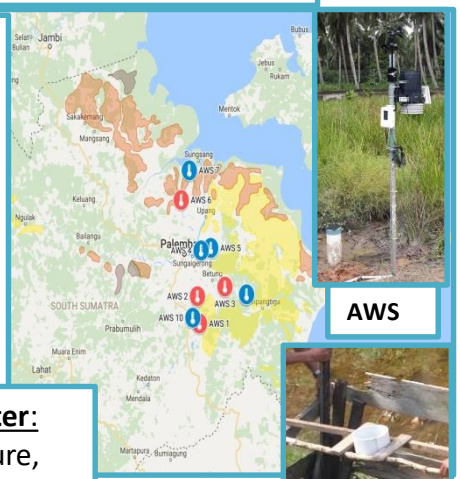
1. Relative Humidity
2. Temperature
3. Vapor density
4. liquid

1. AWS and AWLR Installations

AWS and AWLR Installations were based on peatlands distributions and the availability of facilities a& infrastructures.

AWS and AWLR Locations :

1. Tanjung Api-Api.
2. Karanganyar Village, Muba
3. Kelantan Sakti Plantations Area.
4. Manggala Agni Command Post, Distr. Of Pangkalan Lampam,

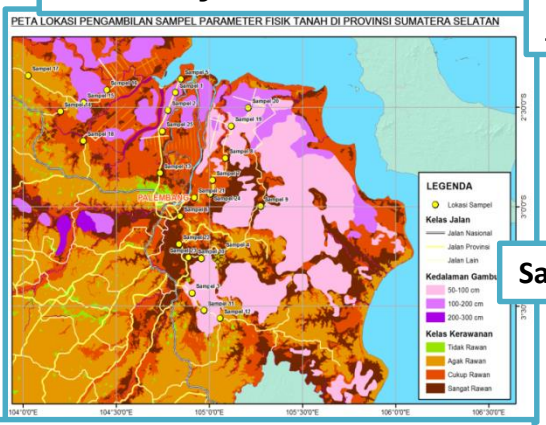


AWS

AWLR

Possible Measured Parameter:
Soil moisture and temperature, water level and rainfall

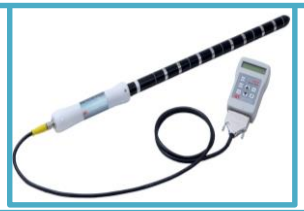
2. Soil Moisture Sample Acquisition, Ground Humidity and Water Table



Site determination is based on peatlands distributions and forest fire risks maps which themselves was based on land physical parameters (± 20 locations).

Instruments Used:

Sample Ring and Soil Drill

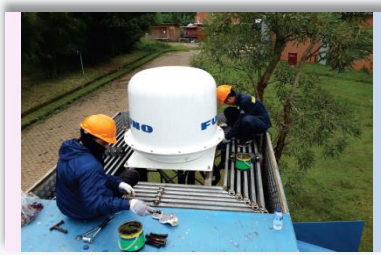


Soil Moisture Profile Probe

R-RAINBOWS

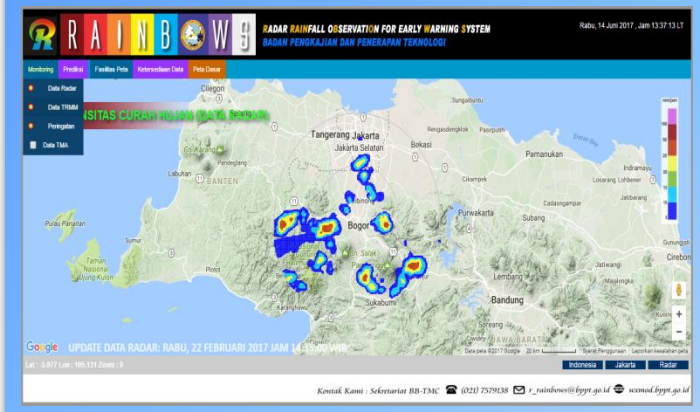
Radar – Rainfall Observation for Early Warning System

SKEMA EWS



R - RAINBOWS is a system of precipitation observation and monitoring using radar for the early warning of flood in Jakarta and surrounding areas which is displayed through an interactive Web-GIS.

Real-Time Rain Monitoring by Radar



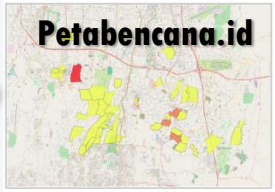
Rain Monitoring (TRMM)

Rain Forecasting (WRF)

Expansion Plan

the possibility of cooperation between rain monitoring (R-RAINBOWS) and inundation monitoring in Jabodetabek area (petabencana.id)

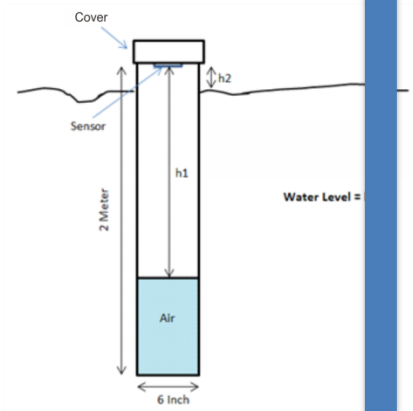
+



wxmod.bppt.go.id/ews_2016

MOKIES
Sistem Monitoring Online Kandungan Air Lahan Gambut Indonesia untuk Early Warning System Karhutla

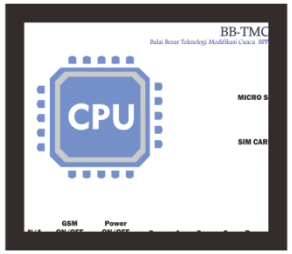
Soil Instrument



Weather Instrument

Wireless

Data Cable



Microcontroller

SMS System

Console

Data Cable

Mini PC

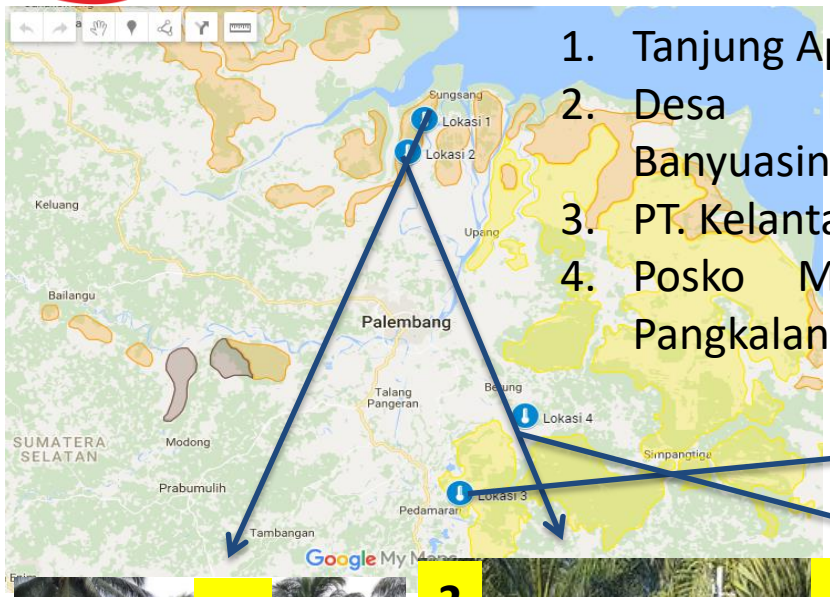
Internet Network

Server

Monitoring

SMOKIES
Sistem Monitoring Online Kandungan Air Lahan Gambut Indonesia untuk Early Warning System Karhutla

Installed on July 2017



1. Tanjung Api-Api.
2. Desa Karanganyar, Musi Banyuasin
3. PT. Kelantan Sakti
4. Posko Manggala Agni, Kec. Pangkalan Lampam, Kab. OKI.

Calculation of Fire Drought Index

mKBDI (modified Keetch-Byram Drought Index)

$$KBDI^t = KBDI^{t-1} + DF^t - RF^t$$

Modified KBDI*

$$mKBDI^t = mKBDI^{t-1} + DF^t_{adj(Ro,ET)} - RF^t - WTF^t$$

Symbols	Description	Units
$KBDI^{t-1}$	Moisture deficiency (KBDI at $t-1$)	mm
mKBDI	Modified *KBDI*, which considers local climate, soil and hydrological factors	mm
DF	Drought factor	mm
$DF^t_{adj(Ro,ET)}$	Adjusted *DF* which is considered local average annual rainfall and evapotranspiration	mm
RF	Rainfall factor	mm
WTF^t	Water table factor	mm

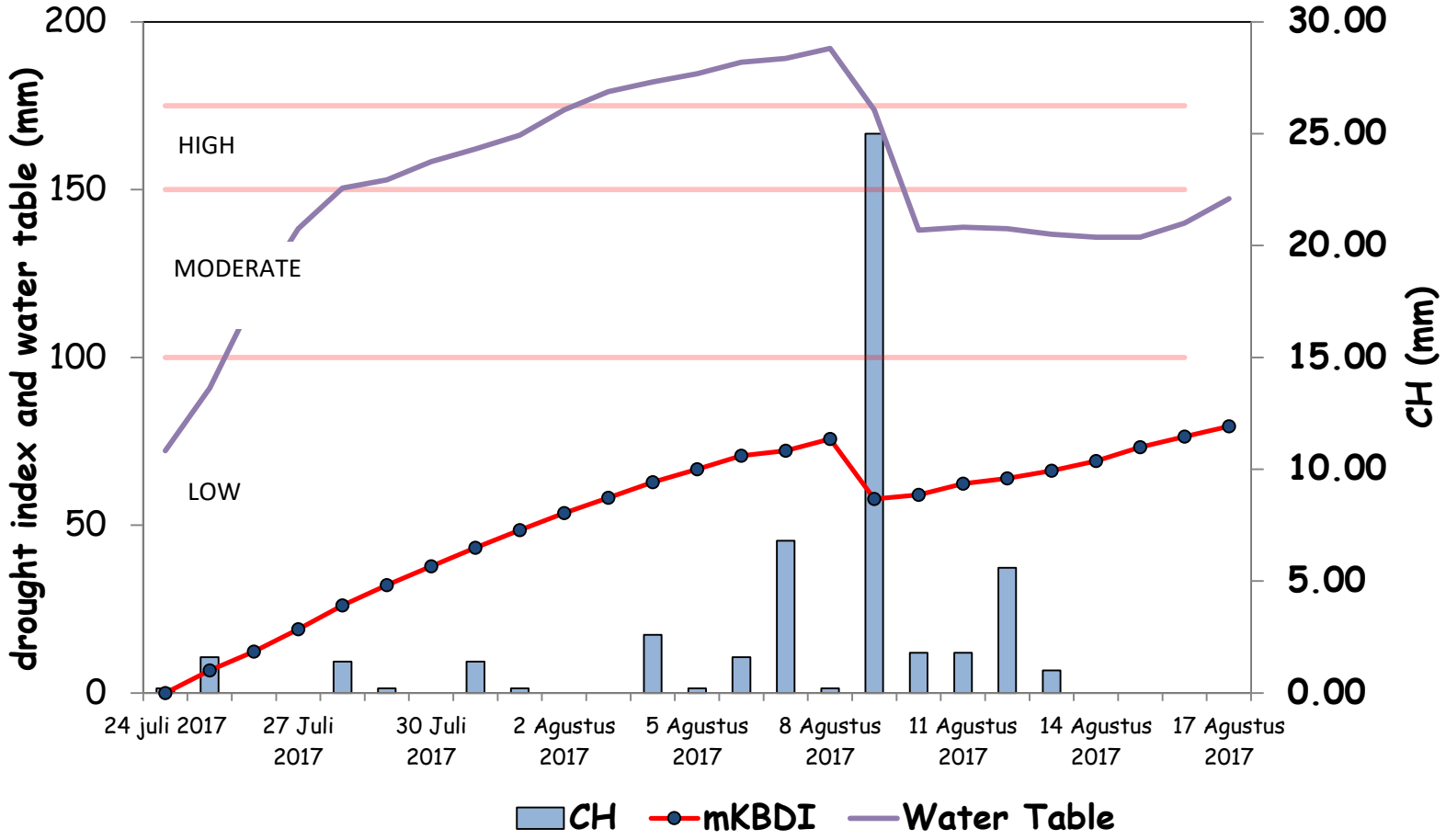
Improvement:

1. Modified by local annual rainfall, soil and hydrological condition. So, new variable has been added i.e. **Water Table Factor (WTF)**
2. Simple input data, only need local annual & daily rainfall and daily maximum air temperature.
3. Daily calculation

*Taufik M, BI Setiawan, HAJ Van Lanen. 2015. Modification of a fire drought index for tropical wetland ecosystems by including water table depth. Agricultural and Forest Meteorology 203 (2015) 1–10. dx.doi.org/10.1016/j.agrformet.2014.12.006

Example:

Calculation of mKBDI Drought Index in Tj. Api-api
Period: 24 July– 17 August 2017



THANK YOU

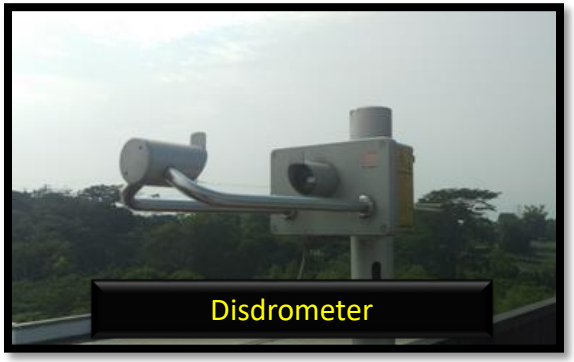
Badan Pengkajian dan Penerapan Teknologi

WEATHER OBSERVATIONS INSTRUMENTS


Micro Rain Radar


AWS

Radiometer


Disdrometer


X Band Doppler Radar


3D Anemometer


X Band Doppler Mobile Radar