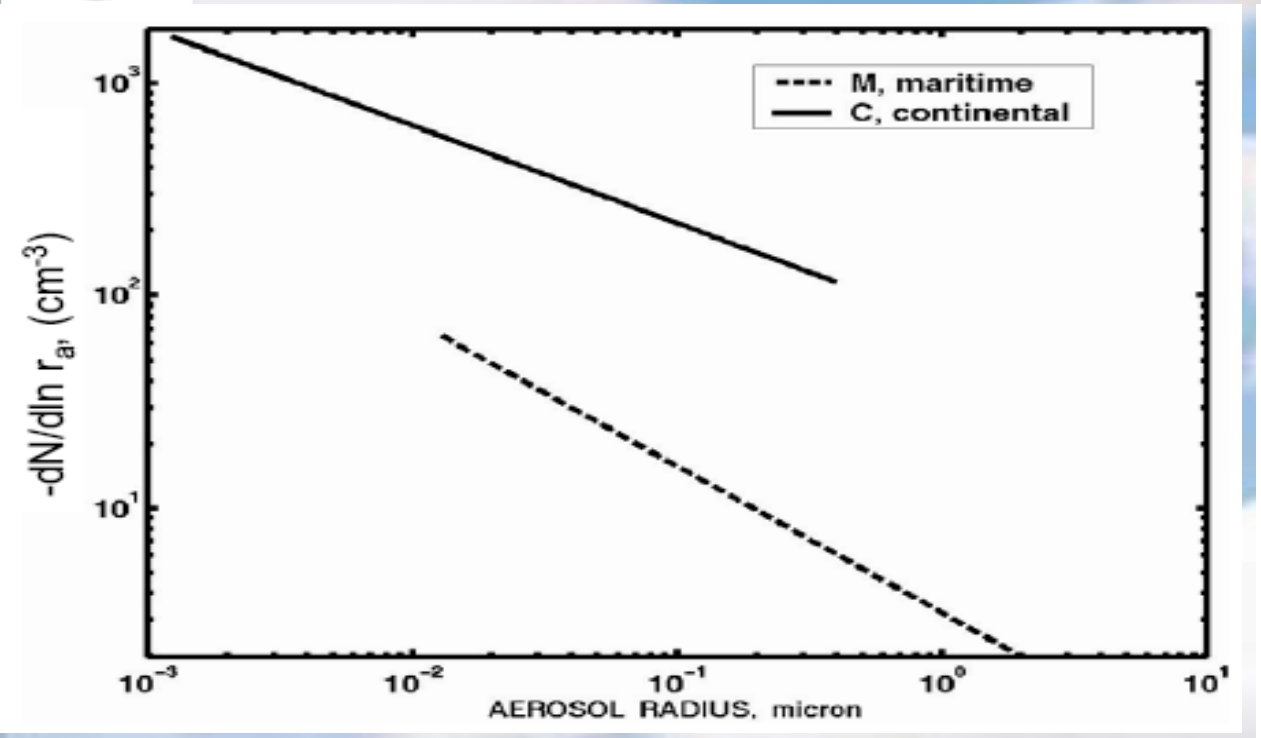
Weather Modification Technology for Rain Reduction In Indonesia.

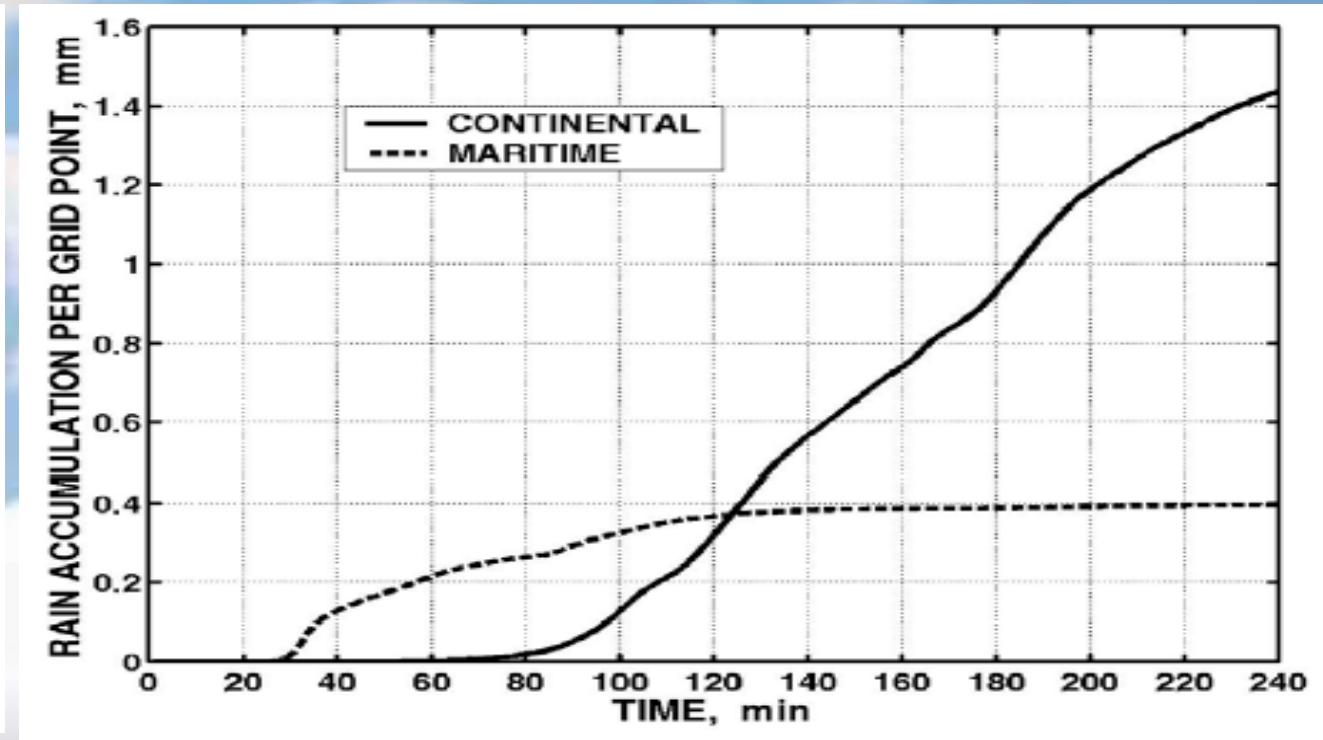
Dr. Tri Handoko Seto

Director of The National Laboratory for Weather Modification

ASEAN TRAINING 2019

Thailand, 24th July 2019





Features of Maritime and continent aerosols and clouds (Khain et.al., 2005)

Continent:

Small aerosol (CCN) size but larger amount, Slow to rain, Large rainfall amount

Maritime:

Big aerosol (CCN) size but smaller amount, Quick to rain, Small rainfall amount

Hyderabad
26.9.2010

$CCN_{0.6}$ = 2500 cm^{-3}
Max cloud drops = 600 cm^{-3}

$CCN_{0.6}$ = 200 cm^{-3}
Max cloud drops = 120 cm^{-3}

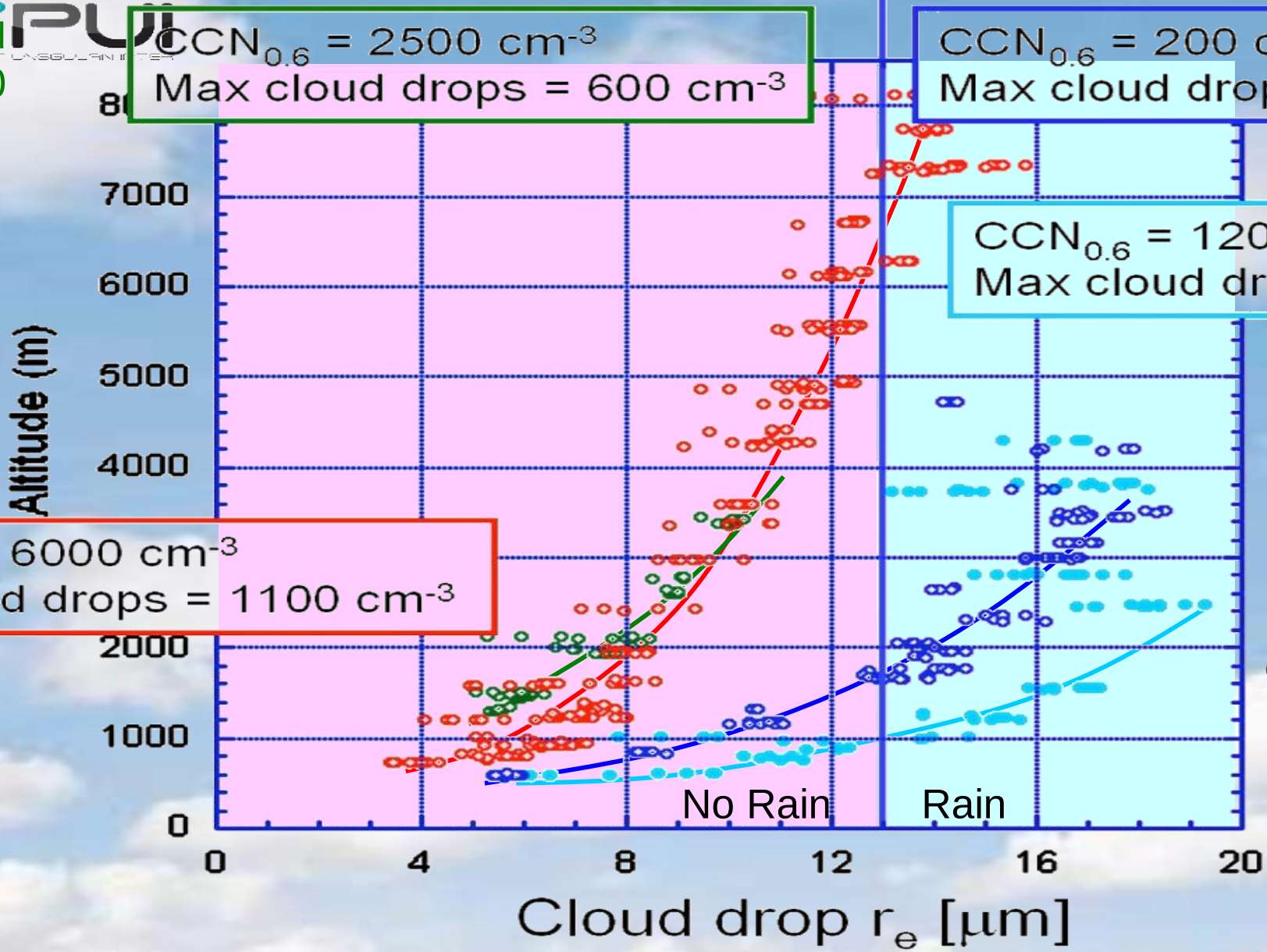
Bay of Bengal
26.9.2010

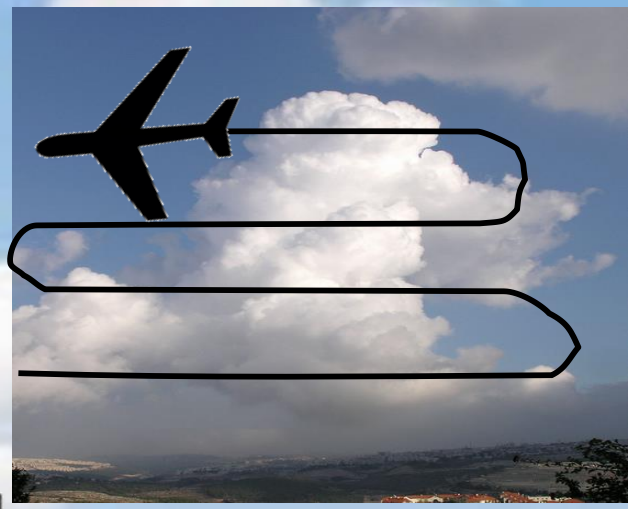
$CCN_{0.6}$ = 120 cm^{-3}
Max cloud drops = 60 cm^{-3}

Bay of Bengal
27.9.2010

$CCN_{0.6}$ = 6000 cm^{-3}
Max cloud drops = 1100 cm^{-3}

Bareilly
23.9.2009





Rosenfeld and Woodley, CAIPEEX-2 Final report to IITM.

Weather Modification Technology for rain reduction

- Studies on rain intensity reduction has been done by many scientists both in the laboratory by using some models and also by field experimentations. Those studies are based on the relationship between aerosol, clouds microphysics and precipitation.
- Yin et al. (2000) states that based on numerical calculation of hygroscopic seeding impact on convective clouds, seeding agents with a size of less than 2 μm could decrease about 22 – 30 % of precipitation.
- Givati and Rosenfeld (2004) showed that urban air pollution in California and Israel may reduce about 15 - 25% of yearly rainfall.
- According to Khain et al. (2005), small cloud condensation nuclei CCN may produce small droplets, which have small collision efficiency, thereby causing deep convective clouds decreasing precipitation.

- Introducing super fine hygroscopic seeding agent into the clouds would then initiate the formation of small droplets that will act as competitor to the existing cloud droplets in the water vapor absorption process within the cloud.
- This method may prevent development of cloud.

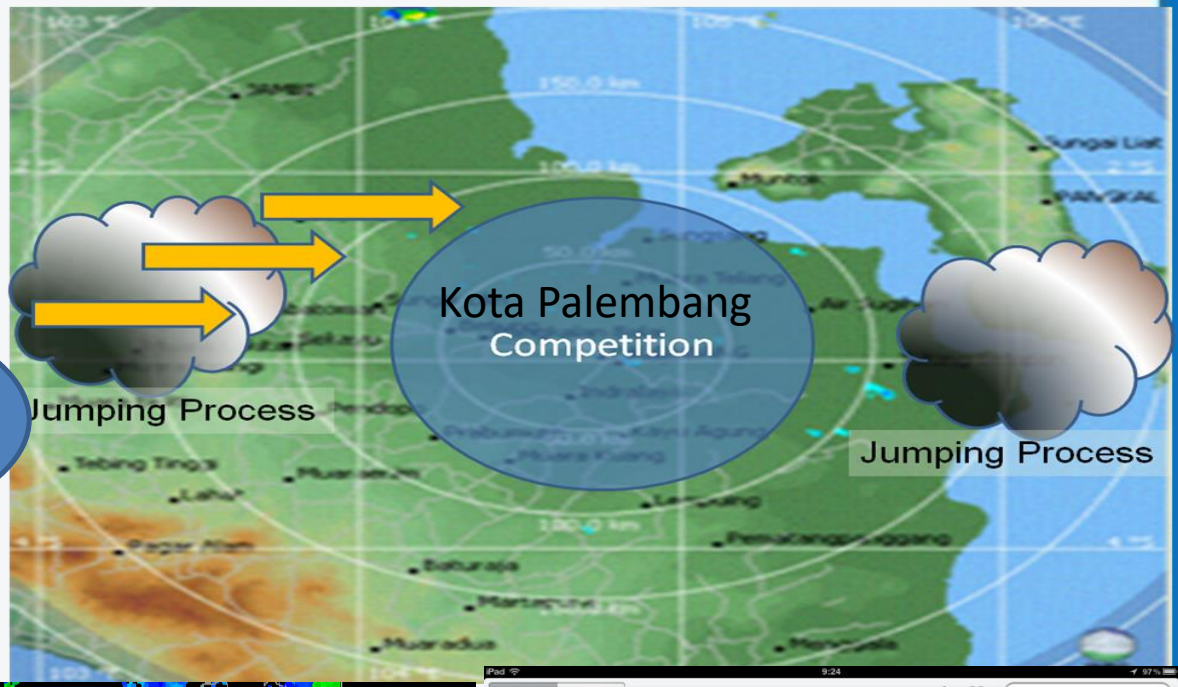
- The best example of "competition mechanism" is during forest fires events. There are too many aerosol present (~2000/ cm^3), which have sizes less than 2 µm, produced by forest fires, cumulus clouds barely developed over the fires and vicinity areas.

Central Borneo, 1 Oct 2011

- Introducing giant hygroscopic seeding agents of about 10 – 100 μm into clouds to increase collision efficiency cause rain may occur shortly.
- It may bypass the CCN population action in determining the initial character of the cloud droplet population, and thus, jumpstart the coalescence process itself (Bruintjes et.al.,PC, 2004) .
- This mechanism will then be applied to developing clouds in the upwind and posses the possibilities to produce rain over the entire target area.
- This "jumping process mechanism" may prevent rainfall at target.

SEA Games 2011 Project
South Sumatera, Indonesia

- User: Agency for Disaster Management
- Period of 25 Oct – 22 Nov, 2011

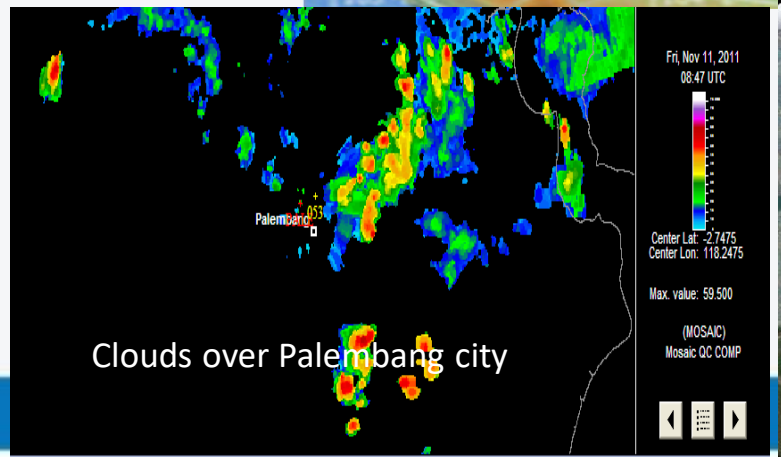


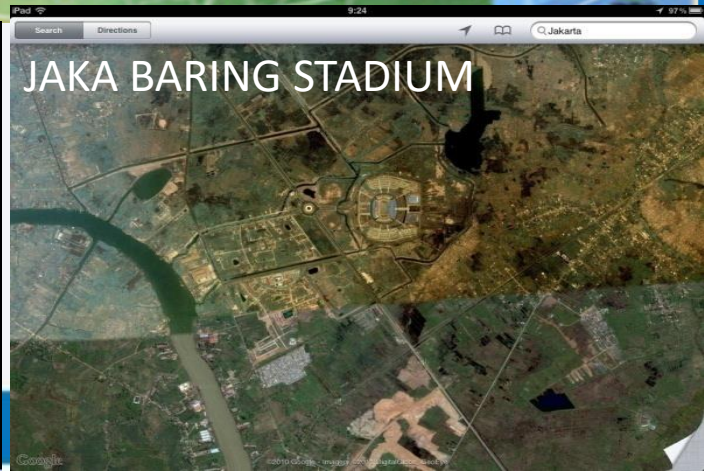
- 80%

-Supported by:

- 4 aircrafts: 2 CASA, 1 Piper Cheyen
  Cessna
- 2 Weather Radars
- 13 Ground-based Generators
- 4 Met. Sta

Command Centre at Palembang airport





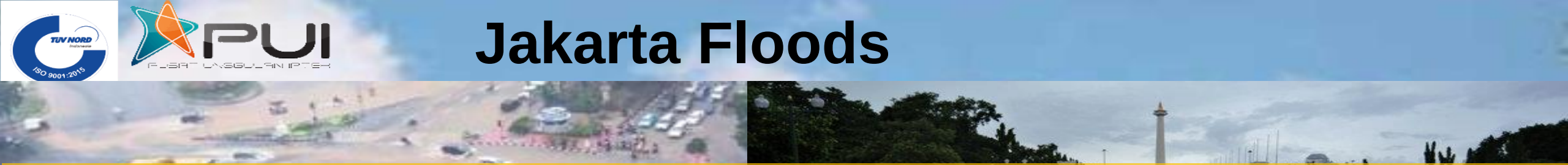
Jakarta Floods

Flood in Jakarta, January 2013 was caused by:

- Monsoon
- MJO
- Cold surge

Daily rainfall on 17 January 2013 was >100 mm

- > 2,000 Milion USD
- 50 people died
- 50,000 people evacuated



Modification for Flood Prevention in Jakarta

Jumping Process

Overseed

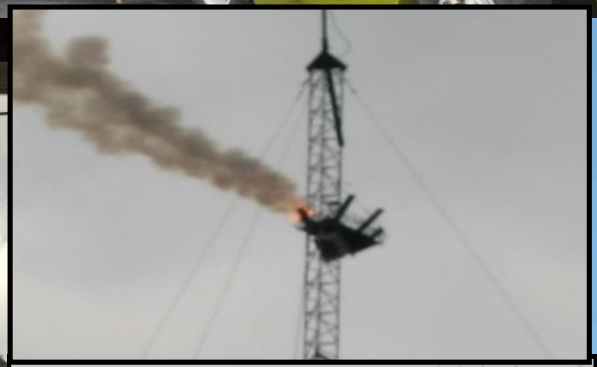
Competition

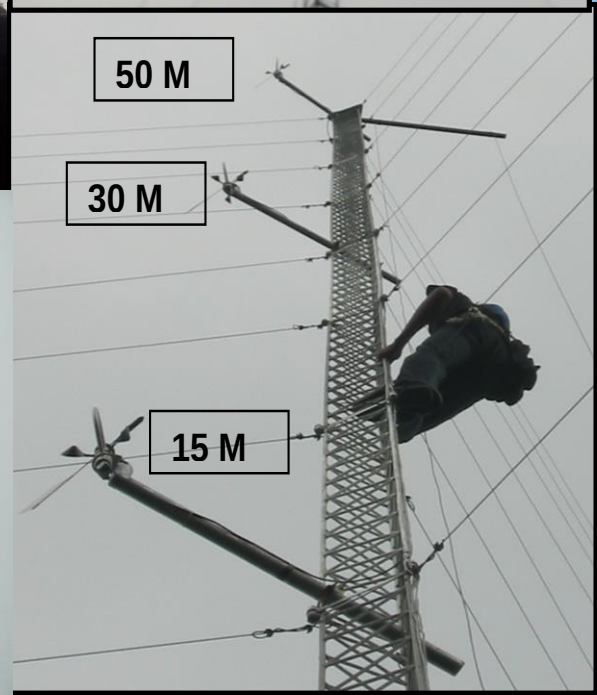
POSKO Pondok Cabe dan Curug
GBG Menara
GBG
Posmet

PETA KERJA TMC
ANTISIPASI BANJIR JAKARTA

Instruments were used:

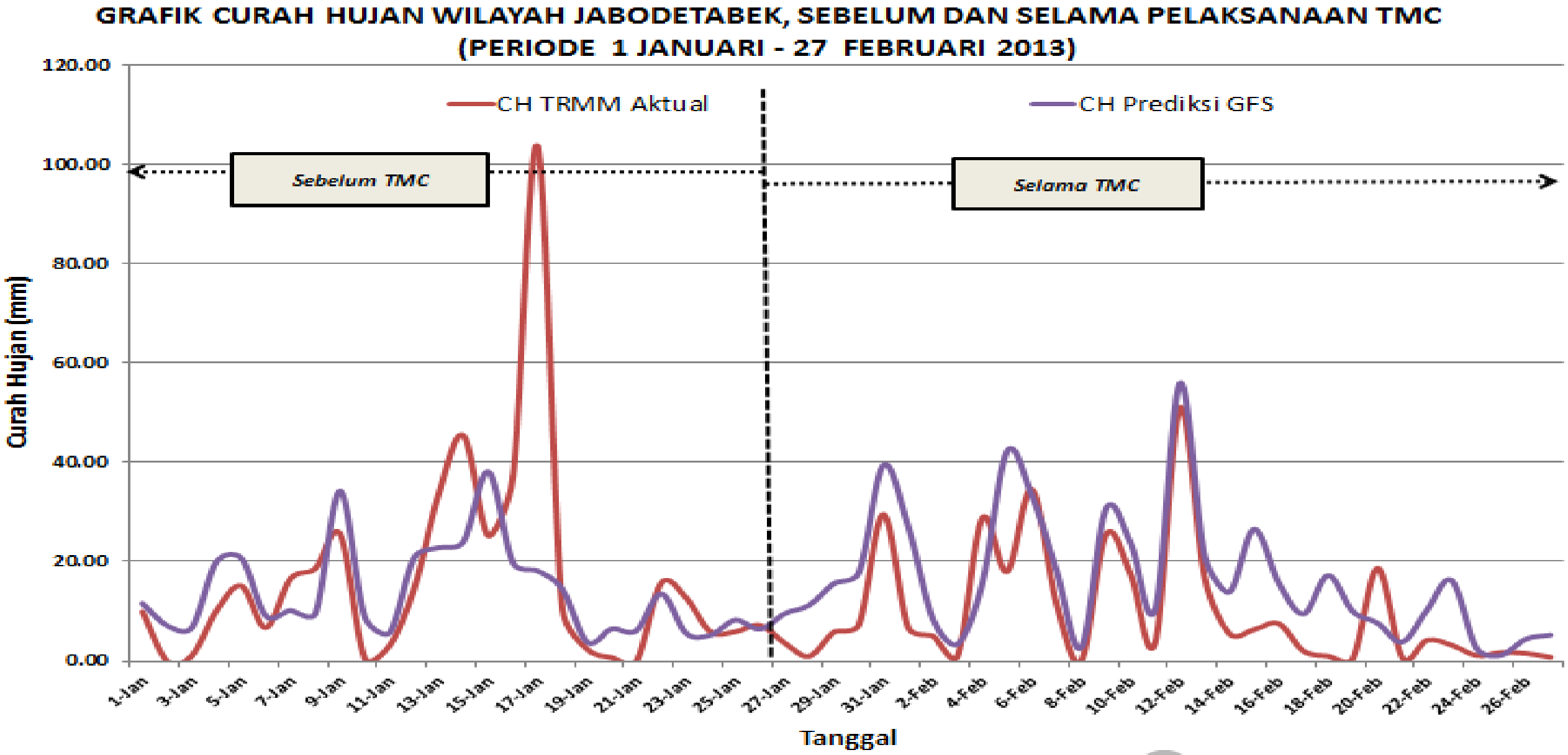
- 3 aircarfts
- 23 location of GBG
- 3 weather radars



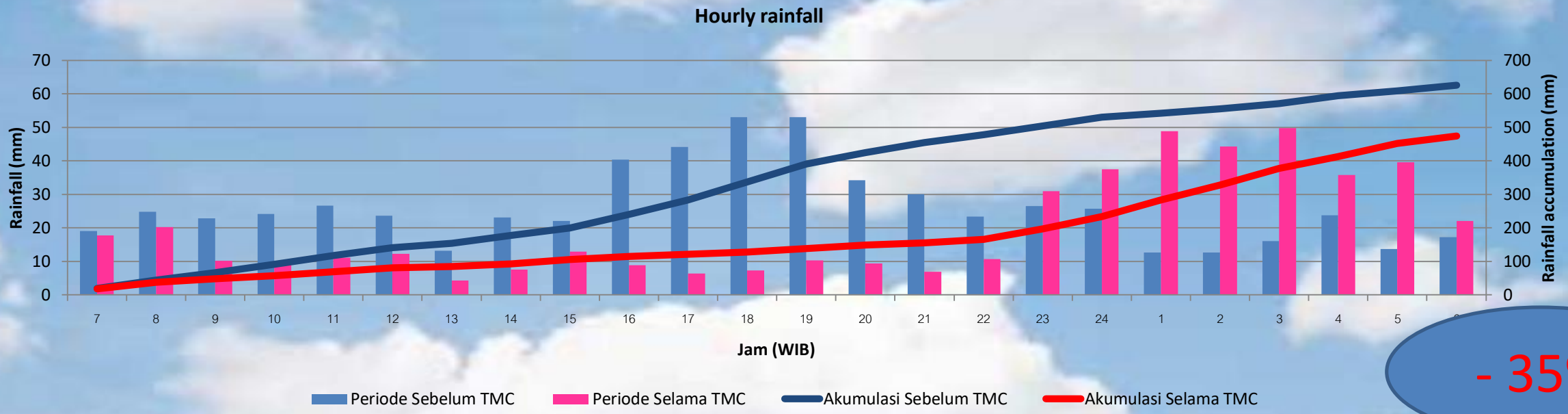


Daily rainfall

Before and During the period of operation



Averaged hourly rainfall
Before and During the period of operation



- 35%

PERIODE	RERATA HISTORIS CH TRMM 2001 - 2012 (mm)	PREDISKSI CH GFS 2013 (mm)	CH PENAKAR 2013 (mm)	CH TRMM AKTUAL 2013 (mm)
01 s.d. 25 Januari (Sebelum TMC)	271.25	351.00	414.11	420.99
26 Jan s.d 27 Februari (Selama TMC)	413.02	537.14	38,6 % 253.43 52,8 %	20,2 % 329.43 38,67 %


BPPT
ERAPAN TEKNOLOGI MODIFIKASI CUACA
KERJASAMA :

ASIA NEWS | March 1, 2013, 6:55 p.m. ET

Indonesia Tries Twist on Rainmaking

Weathering Skepticism, It Sends Planes Over Java With a Mission to Make It Pour—Just Not Near Jakarta

BY BEN OTTO

ABOVE WEST JAVA, Indonesia—On a recent Sunday, a team of government scientists in a small Navy plane rose to an altitude of 12,000 feet over a corner of Java to meet an enormous cumulus cloud.

"That's the one that we want," said one of them, Sunu Tikno, directing the pilots to chart a course into the cloud. As the view went blank, four men in the cargo bay poured dozens of bags of salt, one ton in all, into the sky, their contribution to the world's first known effort to use cloud seeding to try to prevent flooding.

The sortie, ...

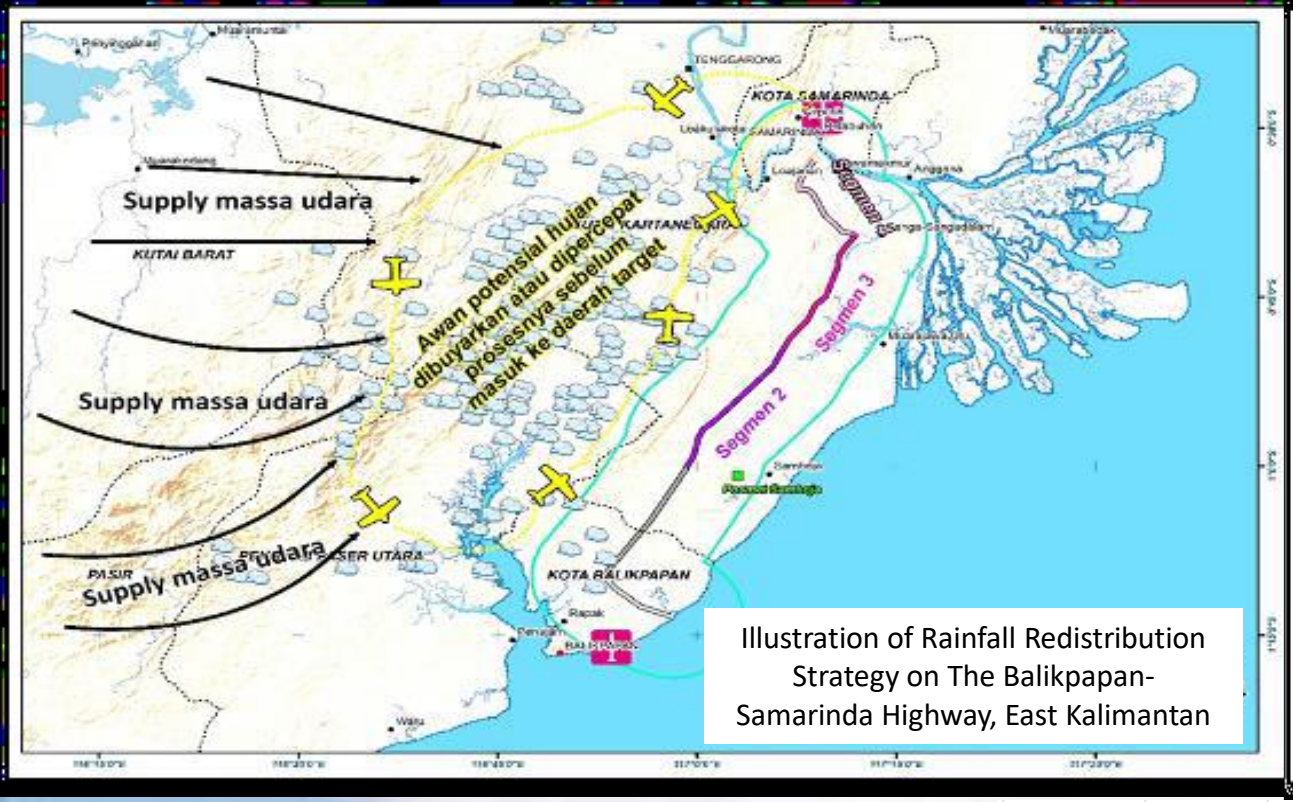
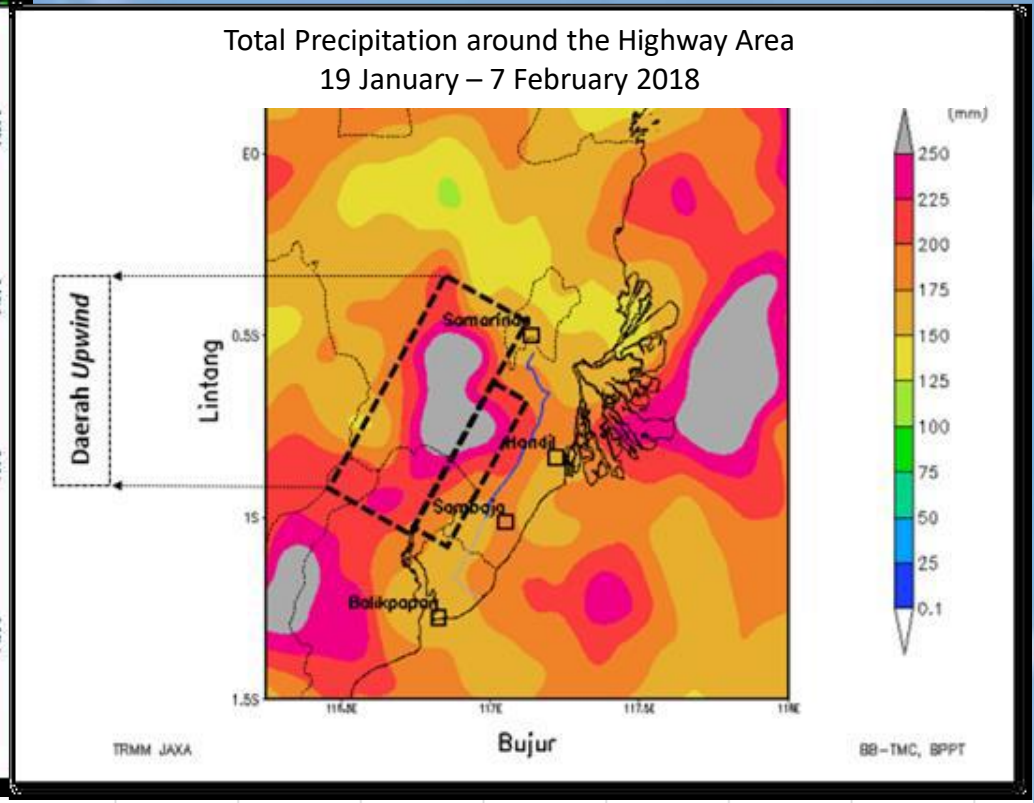
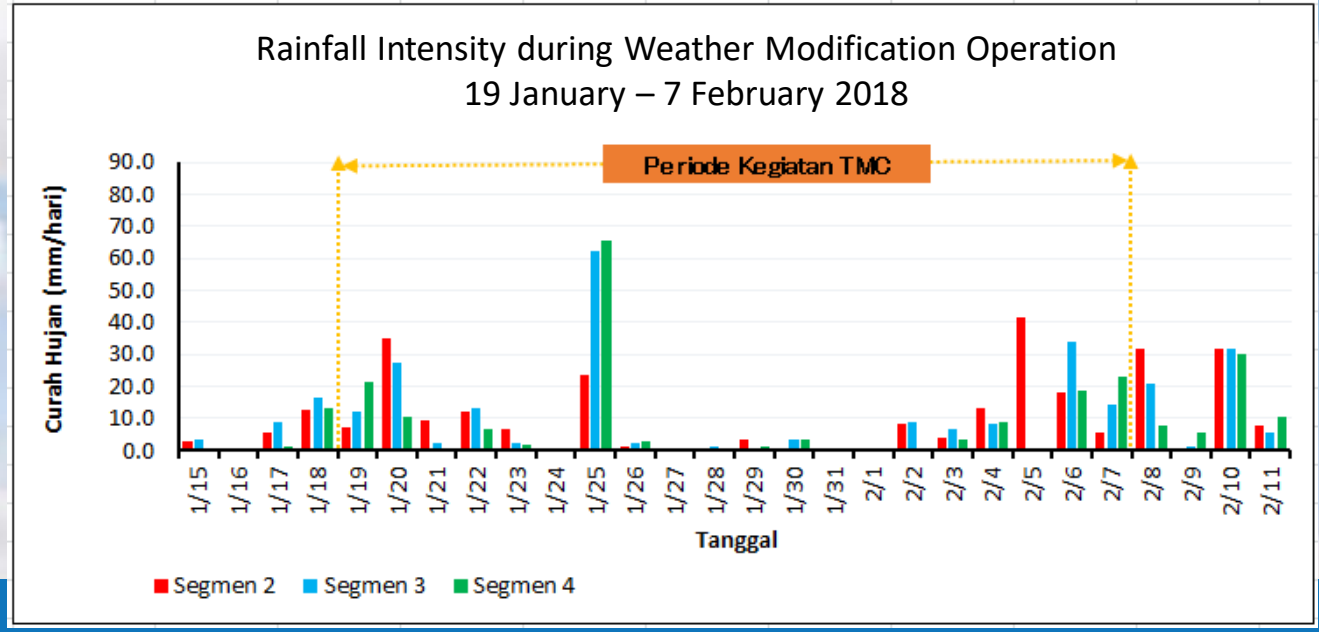


Illustration of Rainfall Redistribution Strategy on The Balikpapan-Samarinda Highway, East Kalimantan



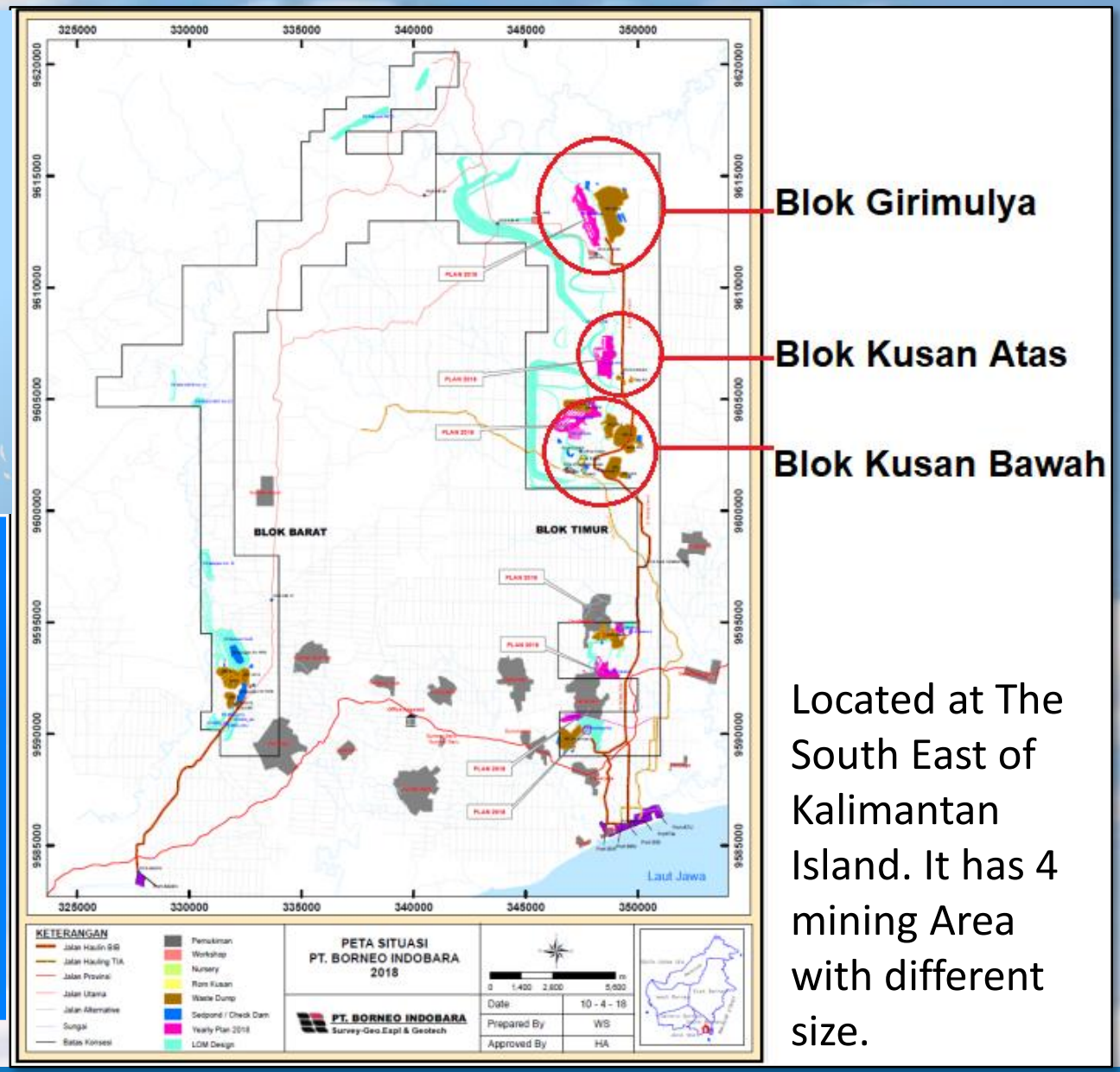
Rain Reduction operation for protecting Toll Road Construction.



How about rain suppression/reduction using competition mechanism with ground-base particle generator?

We design research experiment for rain suppression at coal mining site using ground base particle generator in order to help the coal mining company for reducing operation cost.

Research Location



Blok Girimulya

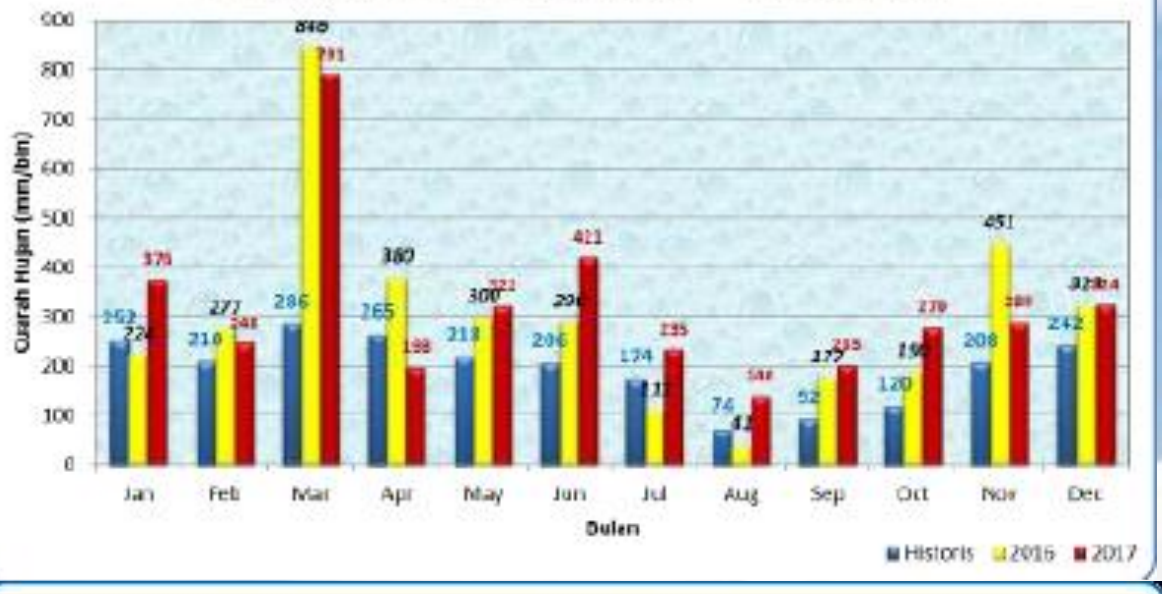
Blok Kusan Atas

Blok Kusan Bawah

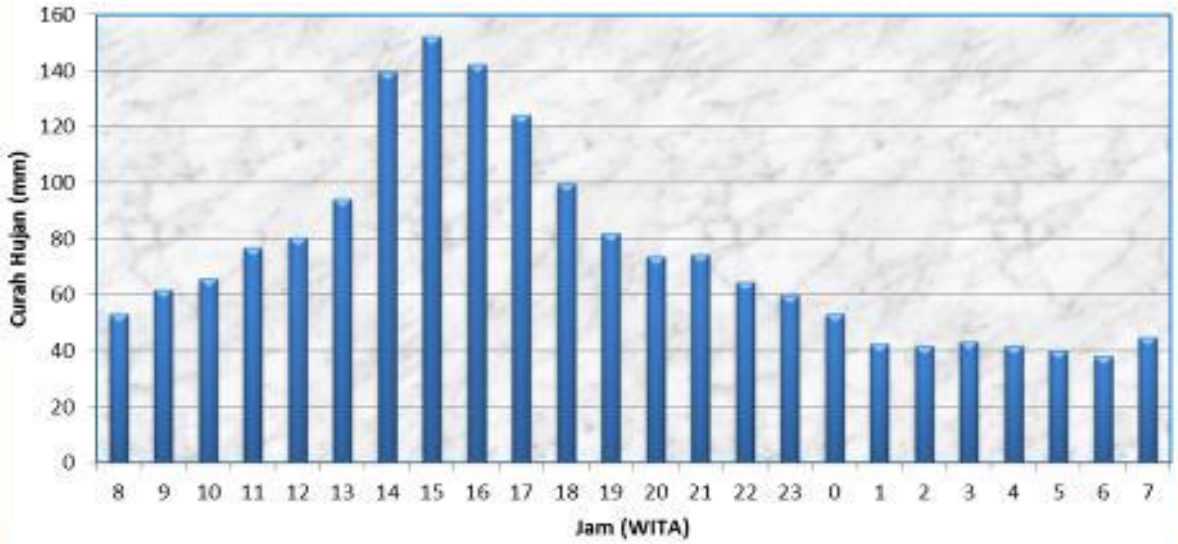
Located at The South East of Kalimantan Island. It has 4 mining Area with different size.

Rainfall Climatology over target area

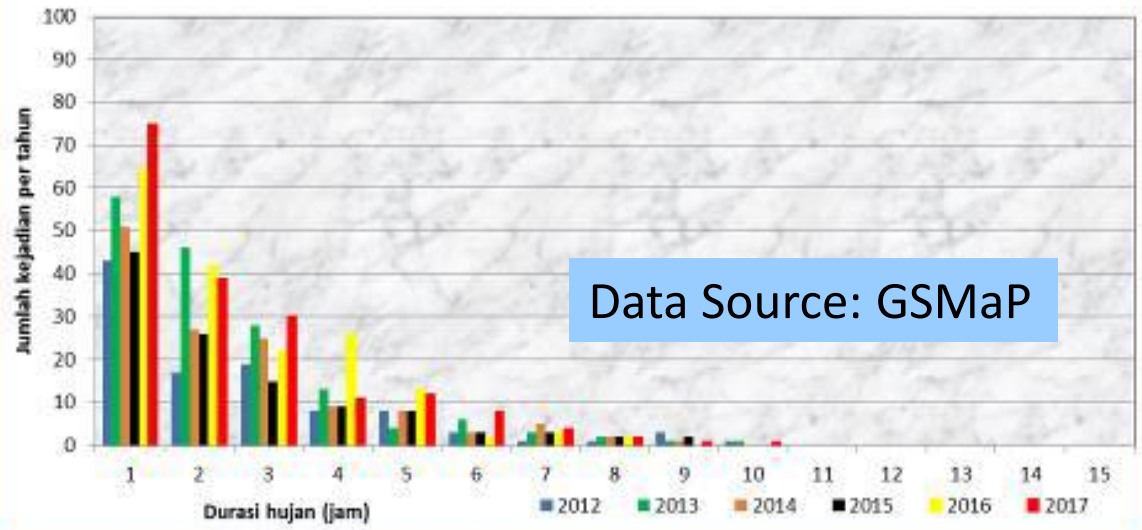
Historical Monthly Rainfall - INDOBARA



Total Historical Rainfall (2009-2017)

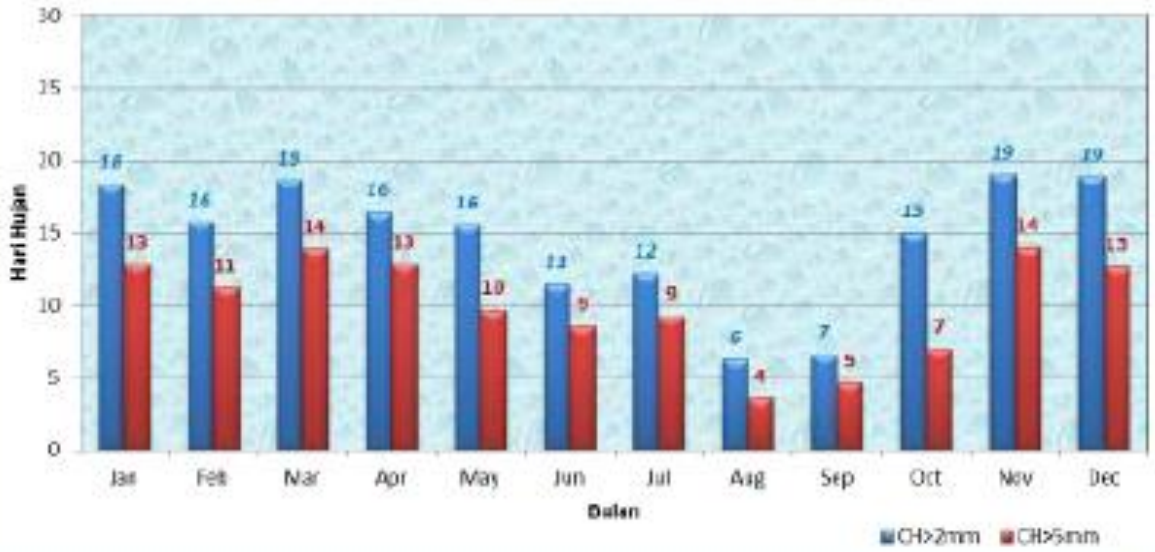


Yearly Average Rainfall Duration : INDOBARA



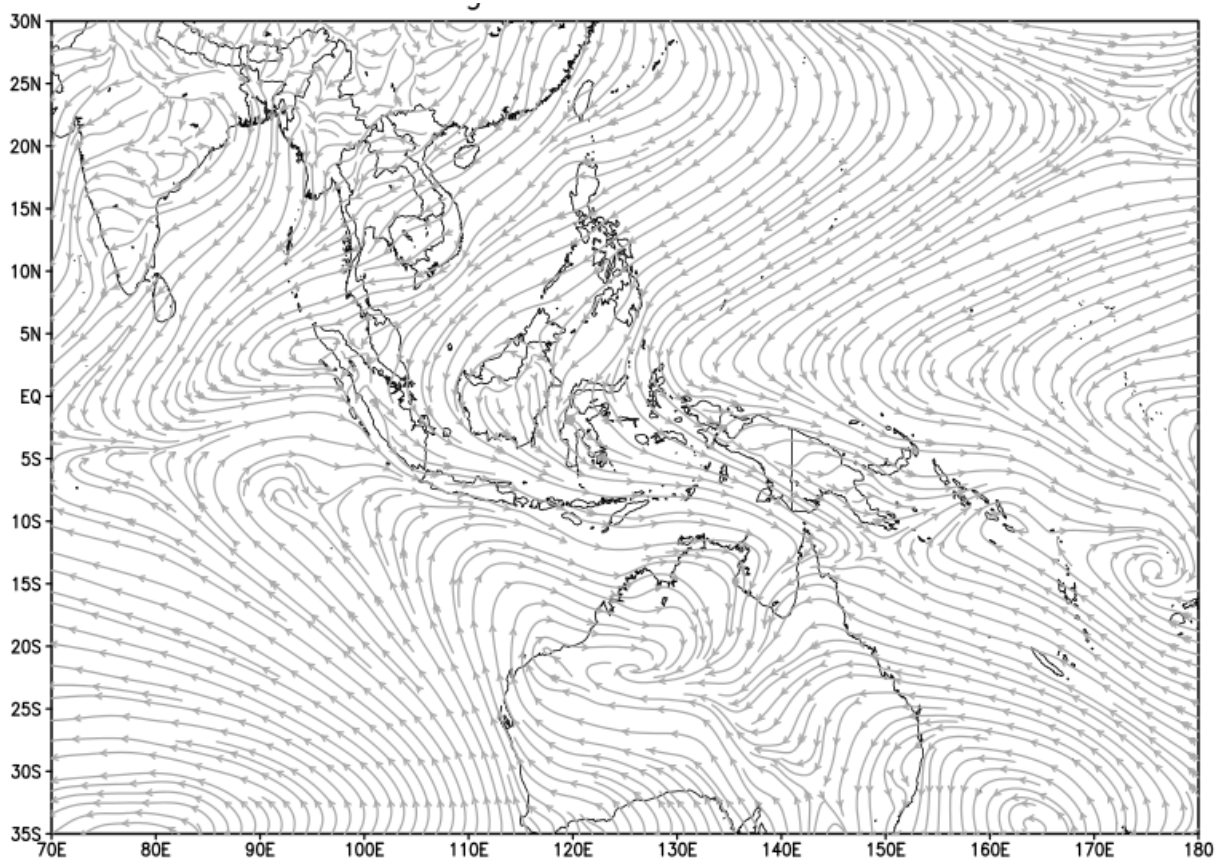
Data Source: GSMaP

Average Days of Rain in The Indobara Area (2009-2017)

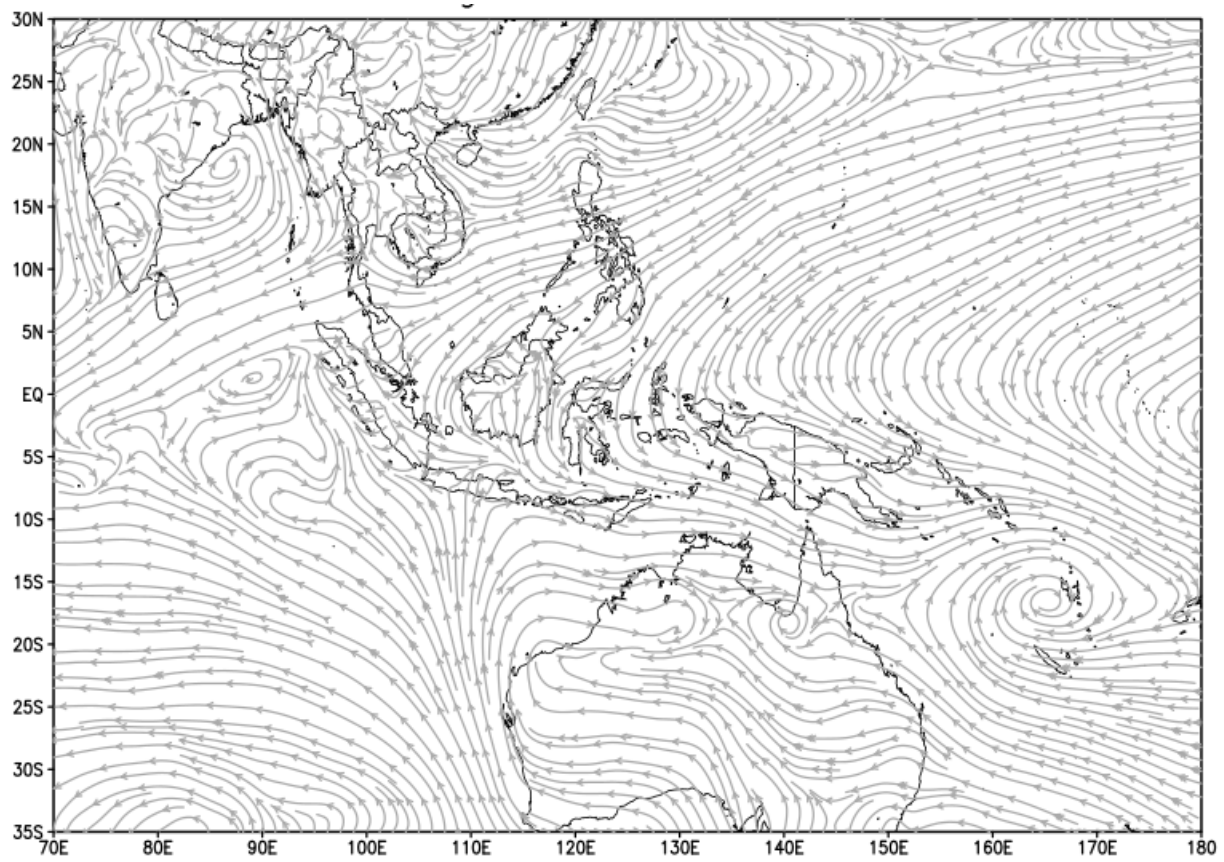


Gradient Wind Analysis

Average Wind Gradient Direction on January 2019



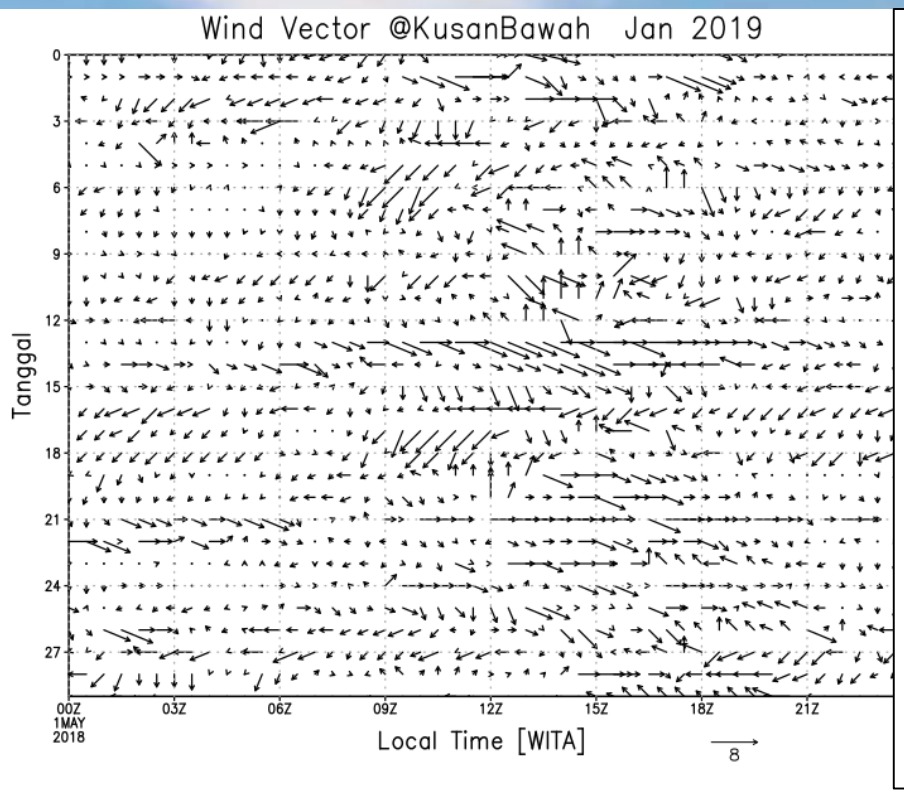
Average Wind Gradient Direction on February 2019

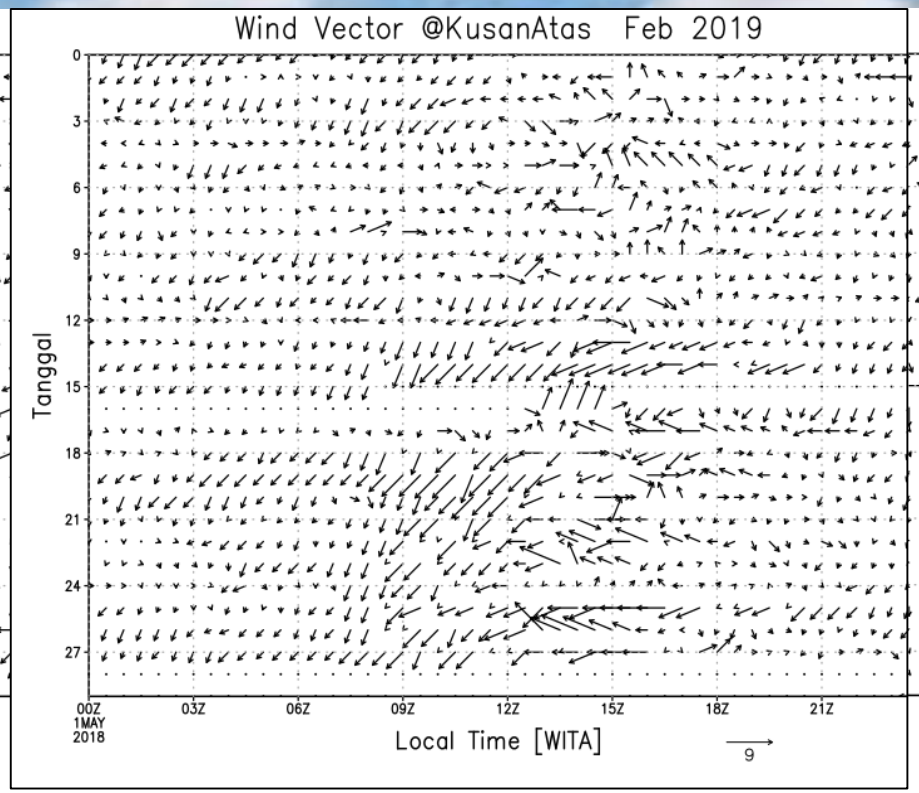


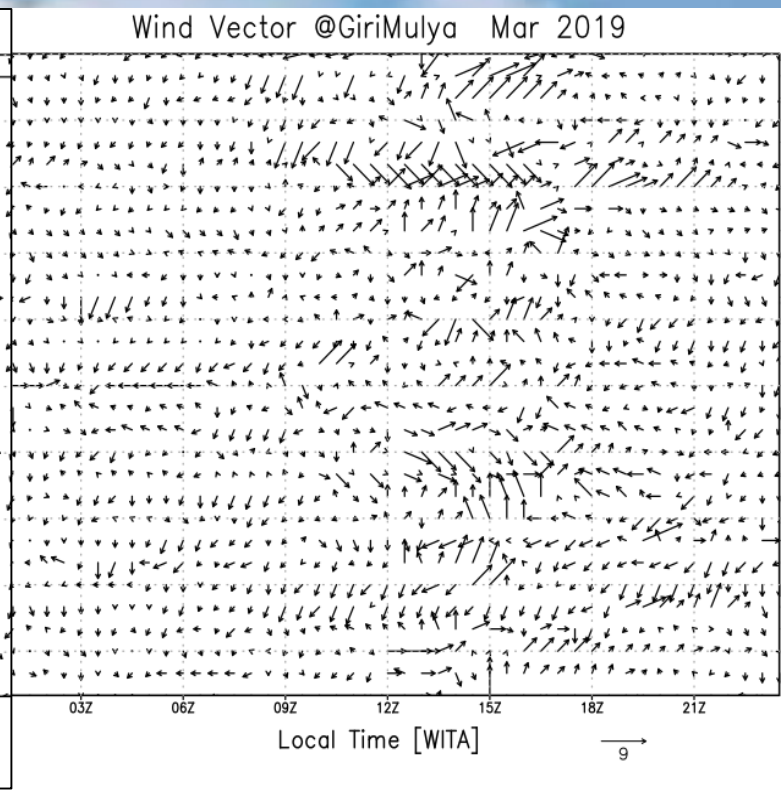
Wind direction analysis was needed to determine the location of the ground particle generator.

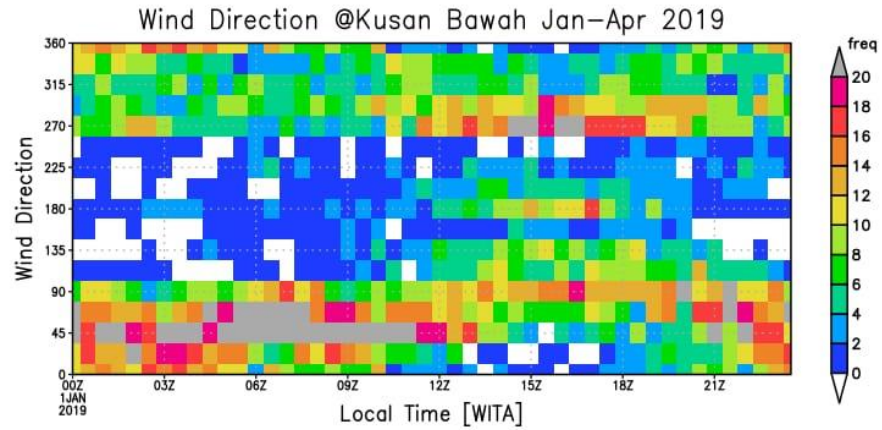
Data Source: ERA-INTERIM

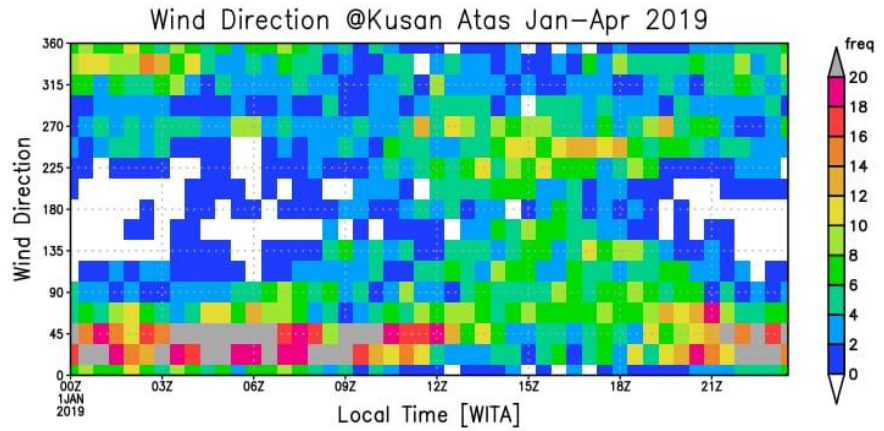
Hourly Surface Wind Analysis

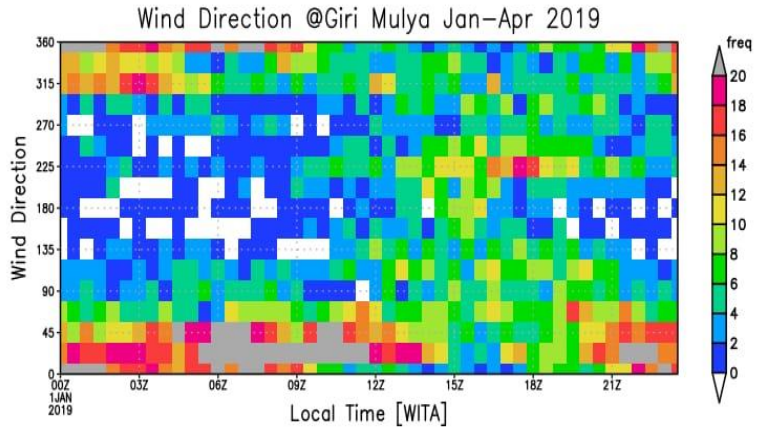












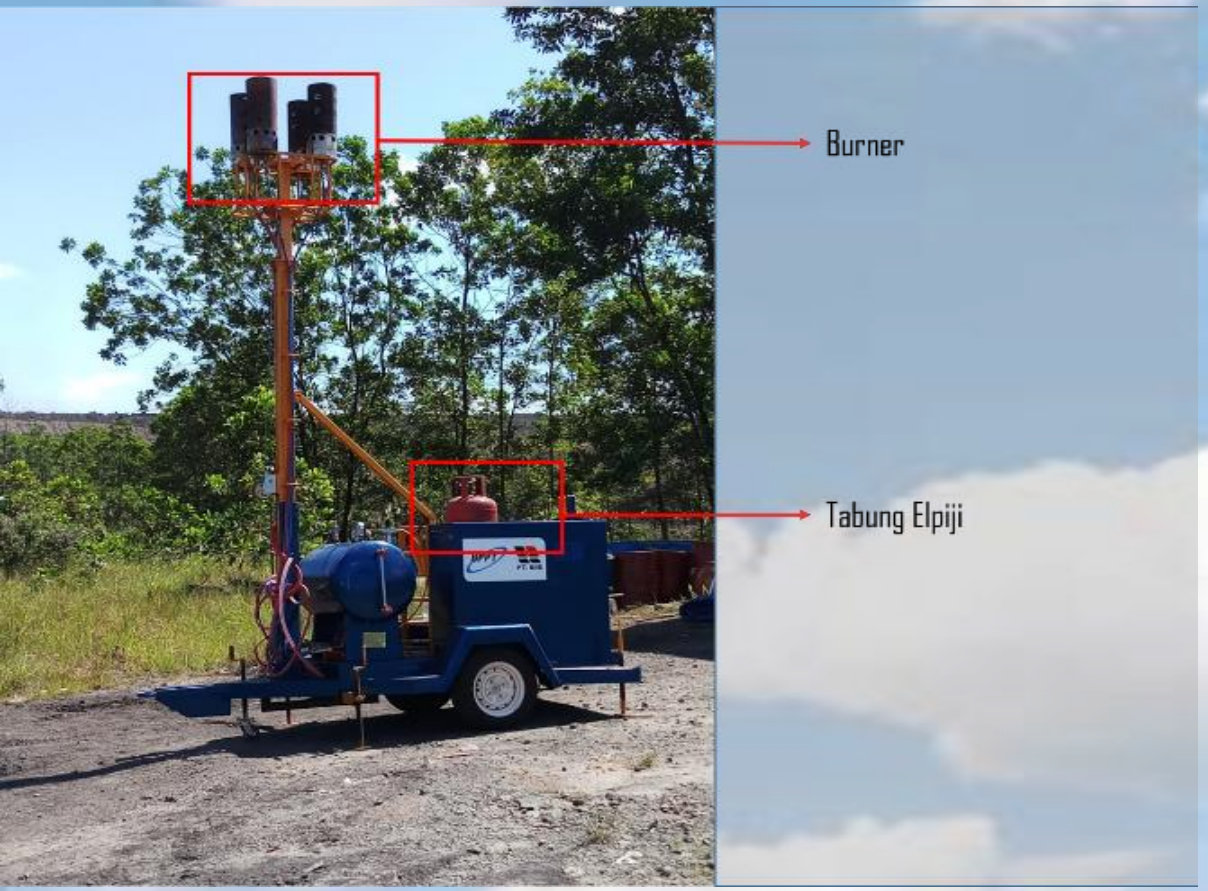
1st Version of Ground Base Generator

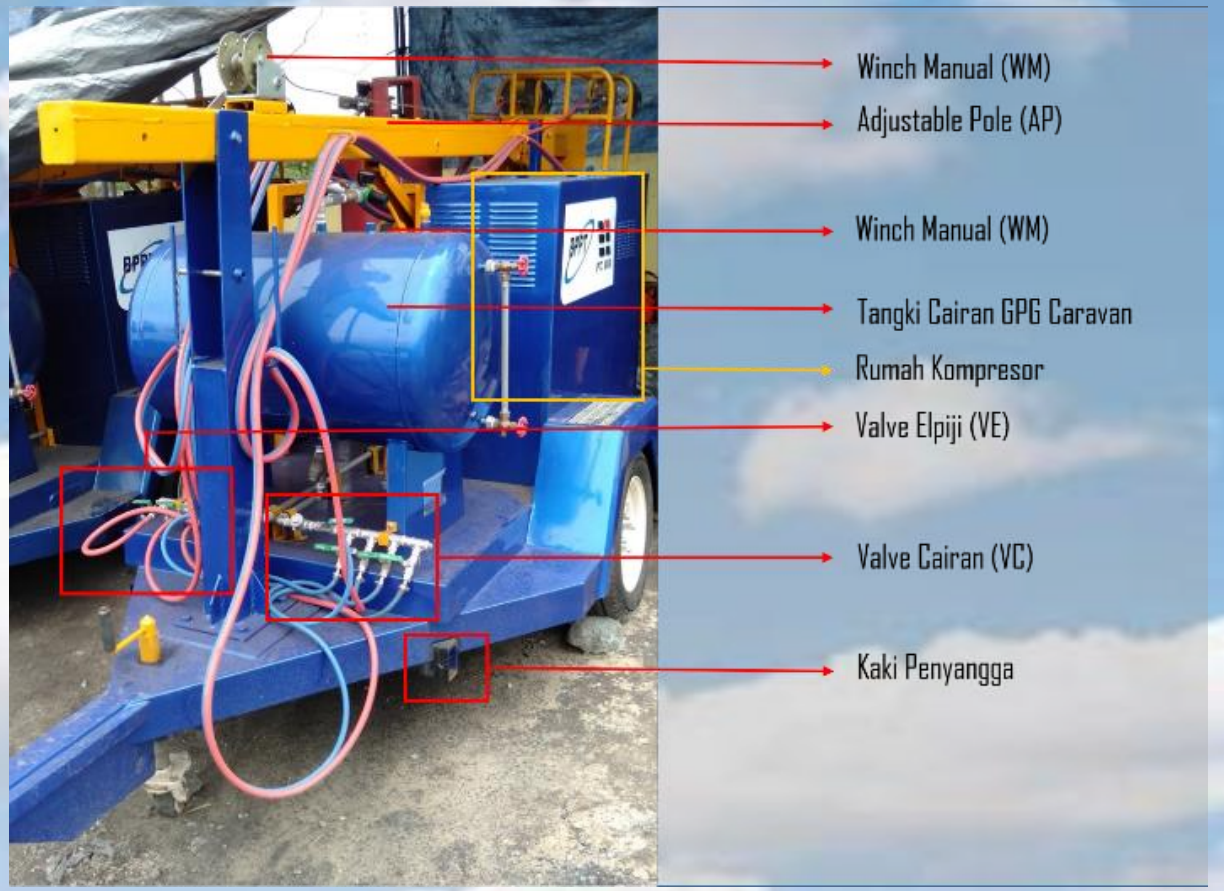
GPG device produces cloud condensation nuclei/CCN with majority sizes being ≤ 0,30 µm with the help of combustion from a ground burner unit.

This device works based on the competition principle in influencing weather and rainfall conditions surrounding the GPG installation area.

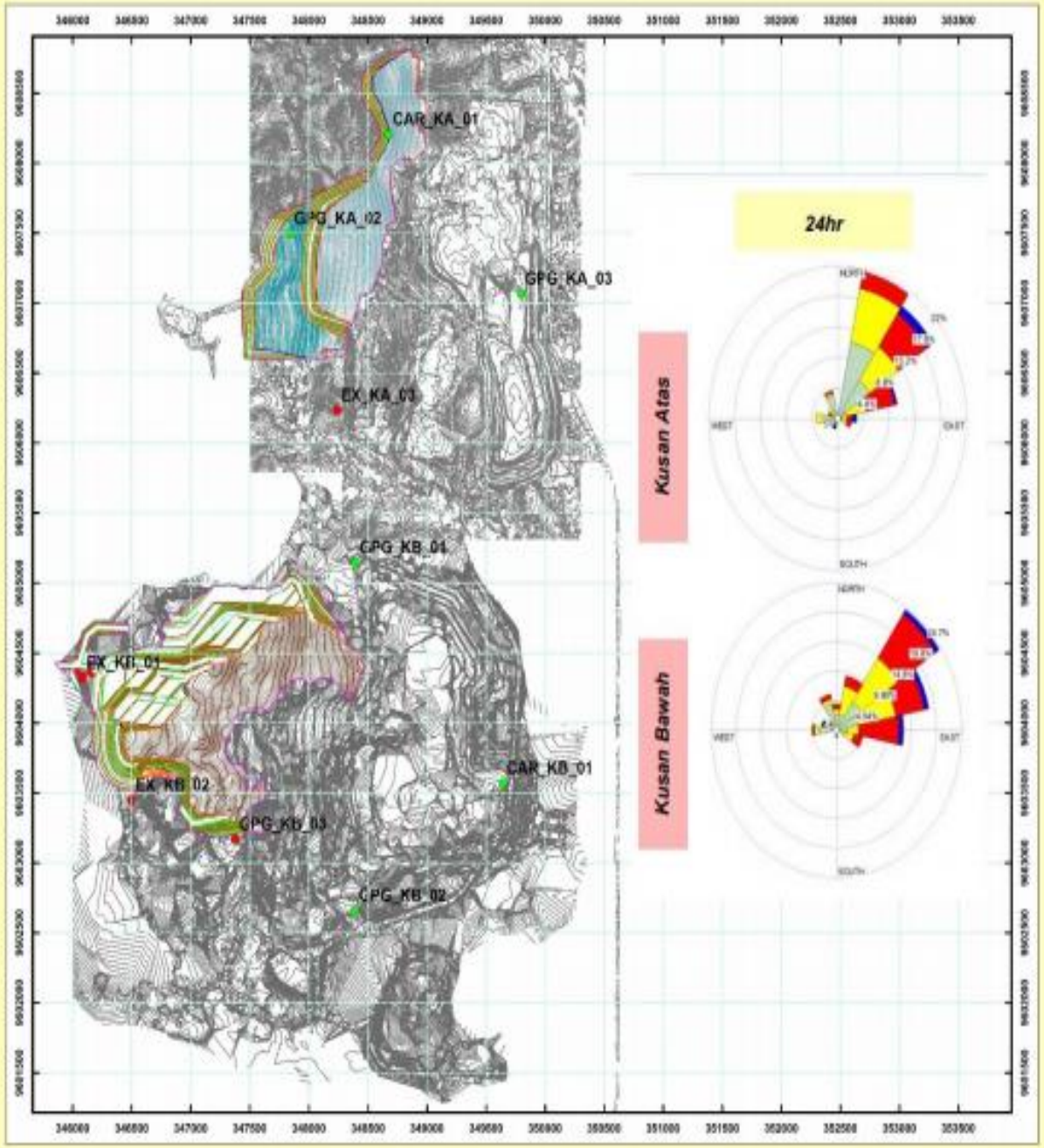
Rain or precipitation occurred due to collision and coalescence process within the clouds which then results in rain. GPG would produce artificial CCN particles in much greater amount compared to natural CCN particles, so that water vapour competition would occur between natural and artificial GPG from the GPG thus disrupting cloud growth and finally reduces rain in the target area.

Improvement of the Base Generator



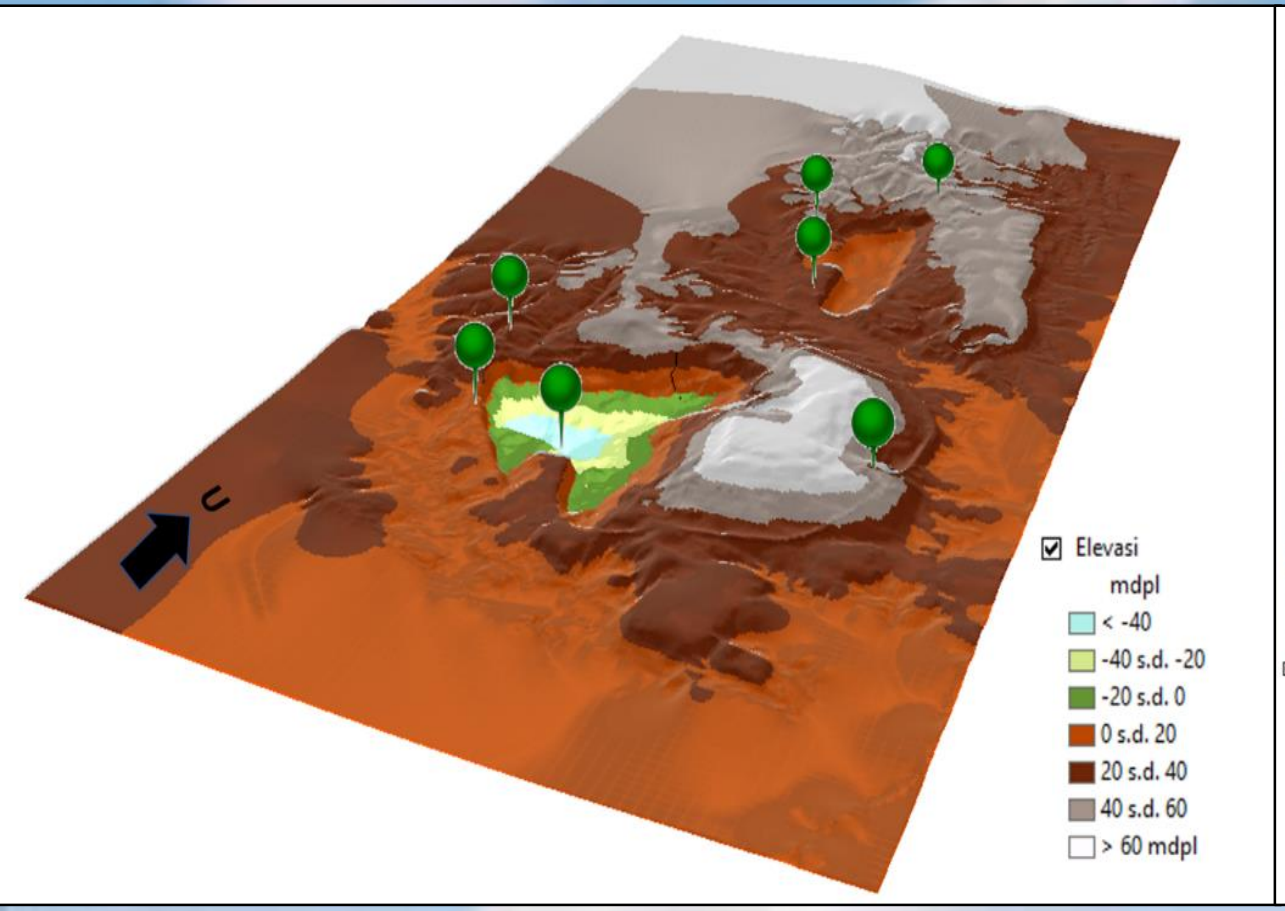


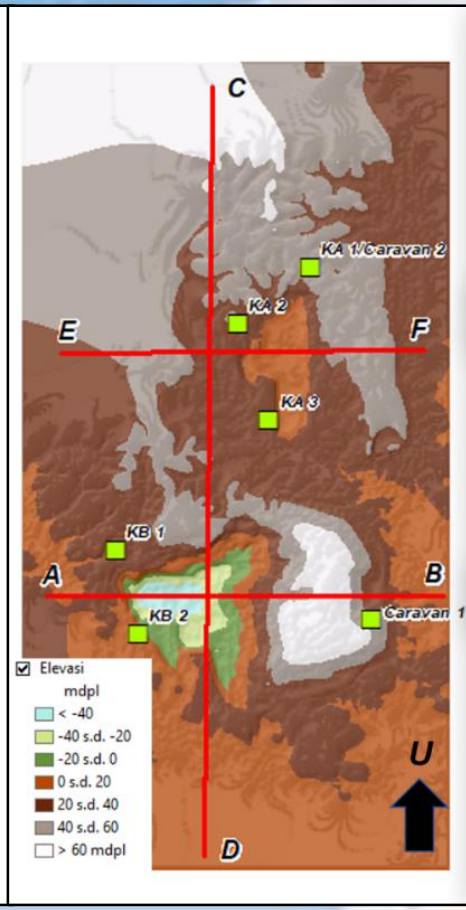
The improvement of the base generator was needed to multiply the number of particle produced and also for mobility

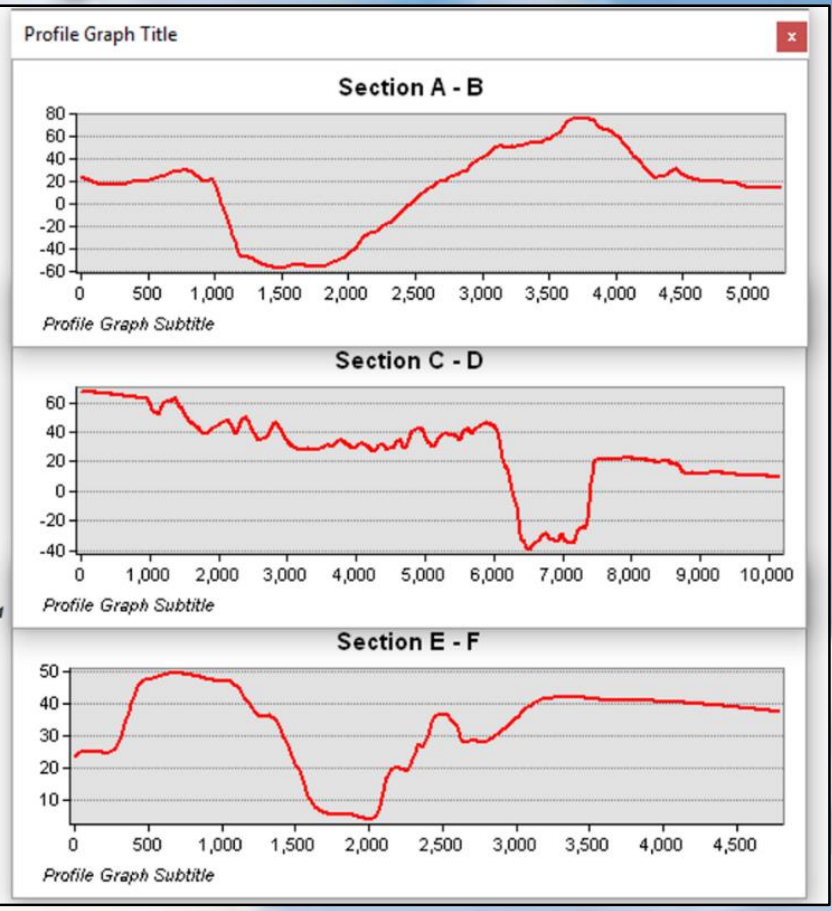


Installation

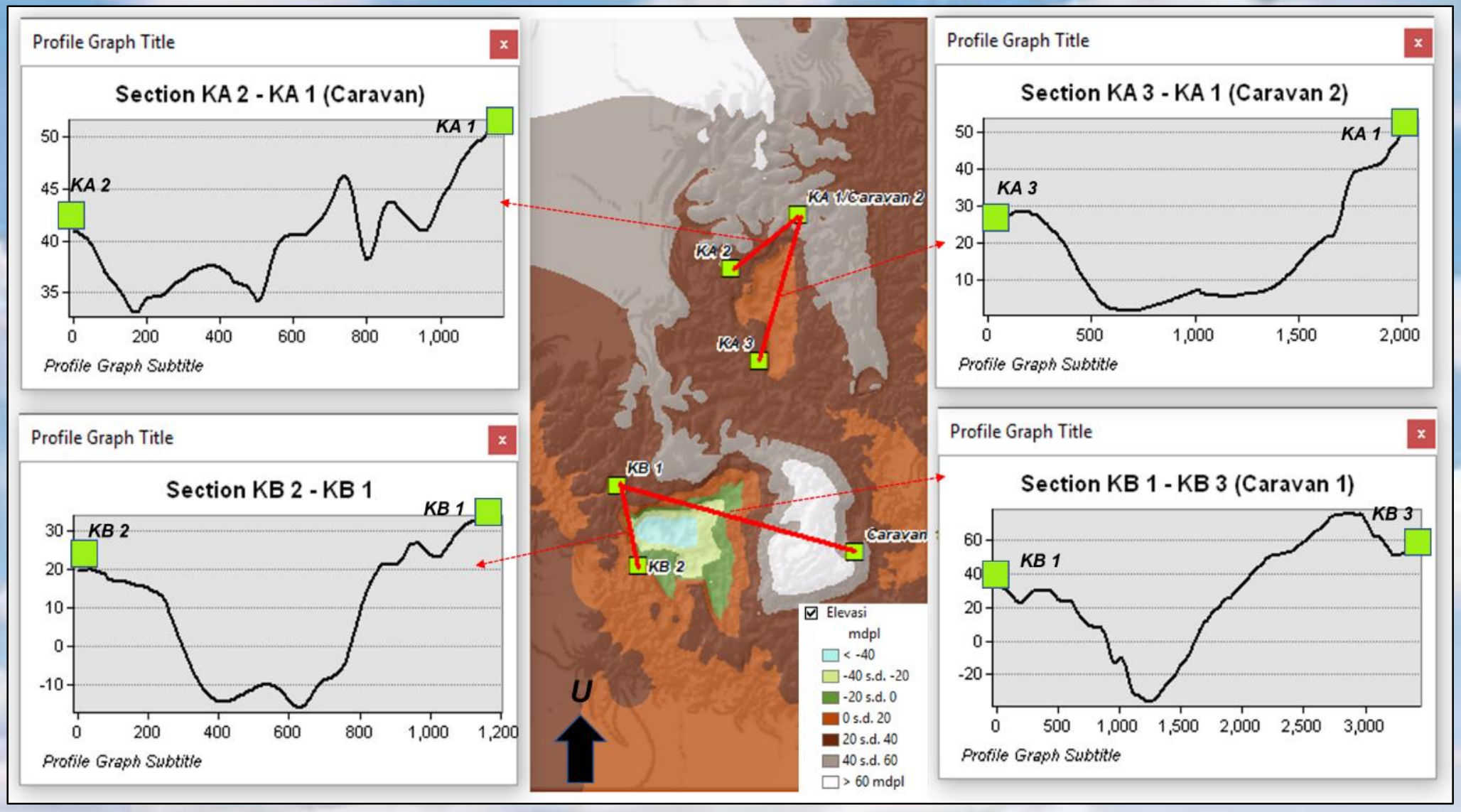
Topography profile of the Target Area





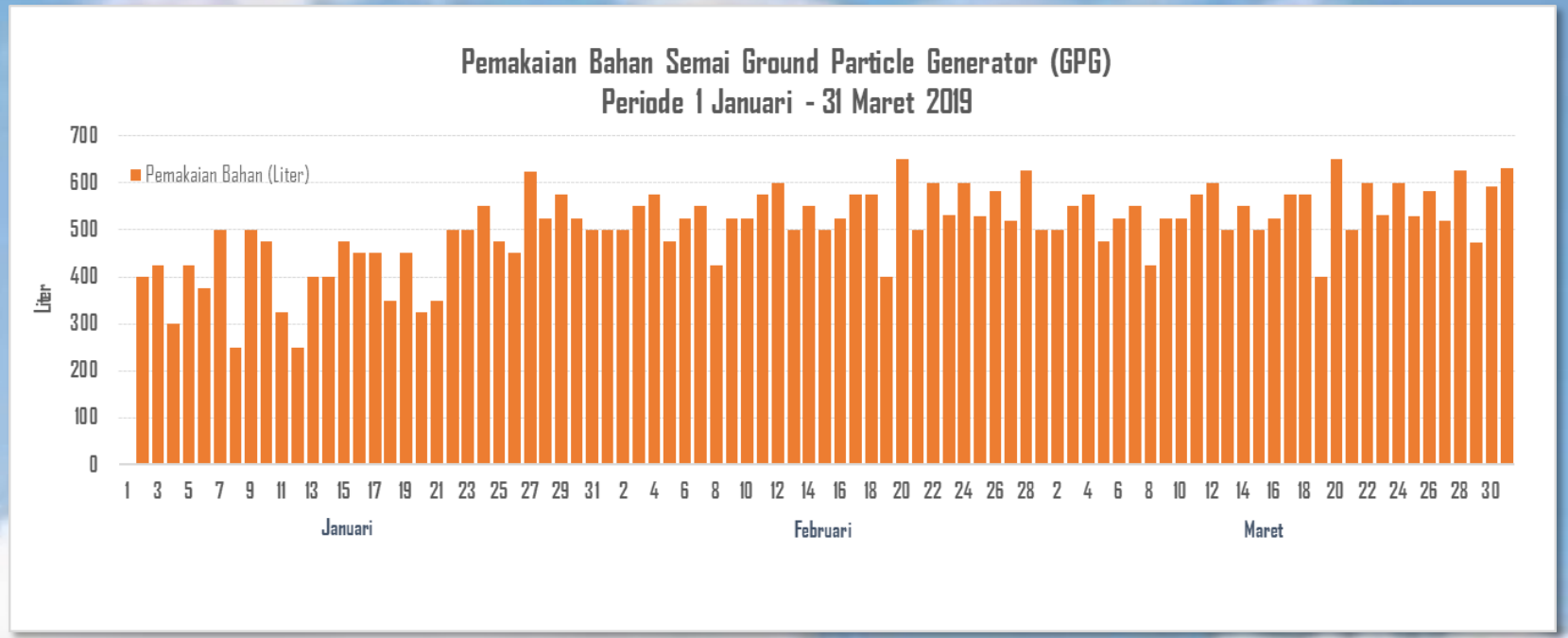


Topography profile for the generator location



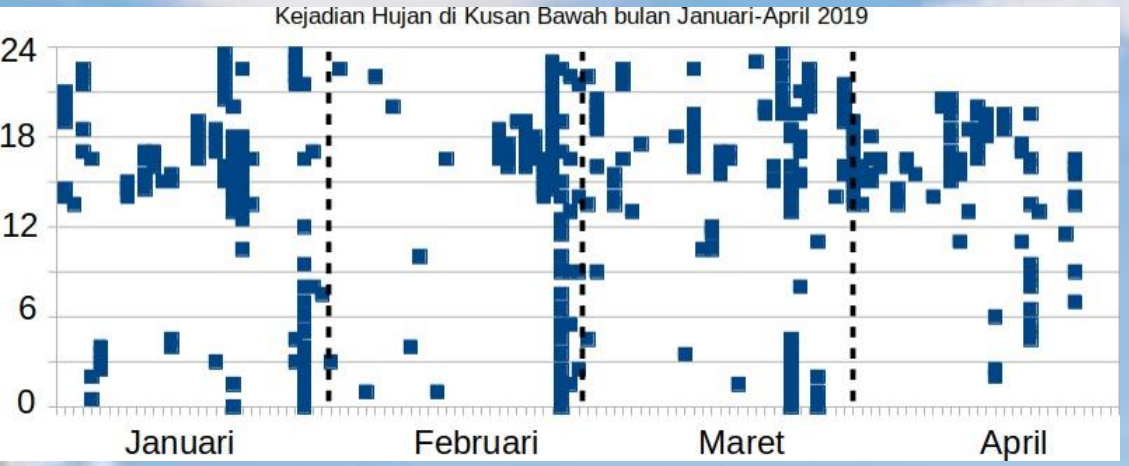
GPG device locations were concentrated around the pit are, there is only 1 GPG unit (KB 3) that is positioned quite far (± 2 Km) from the pit. The diagonal profile seen can be used as an evaluation tool for GPG positioning in field experiments.

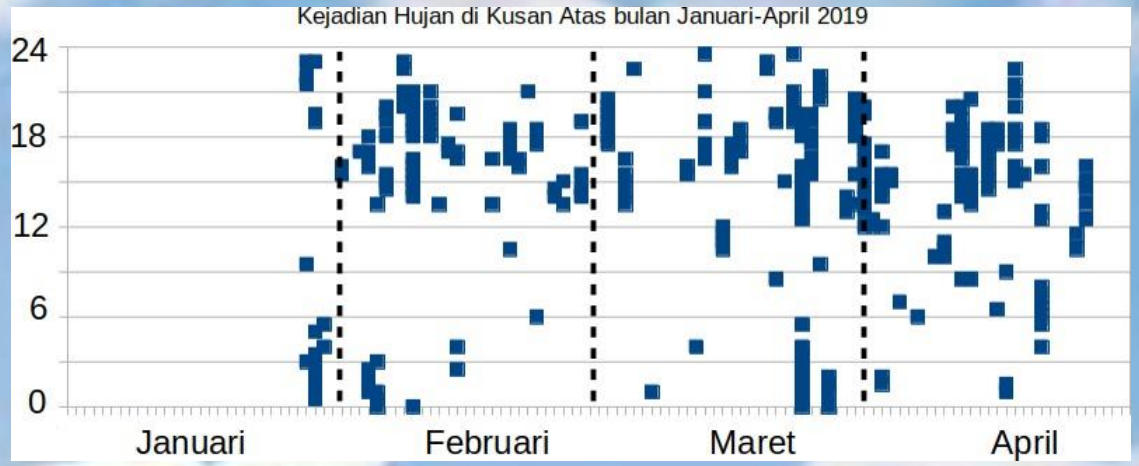
USAGE OF SEEDING MATERIAL

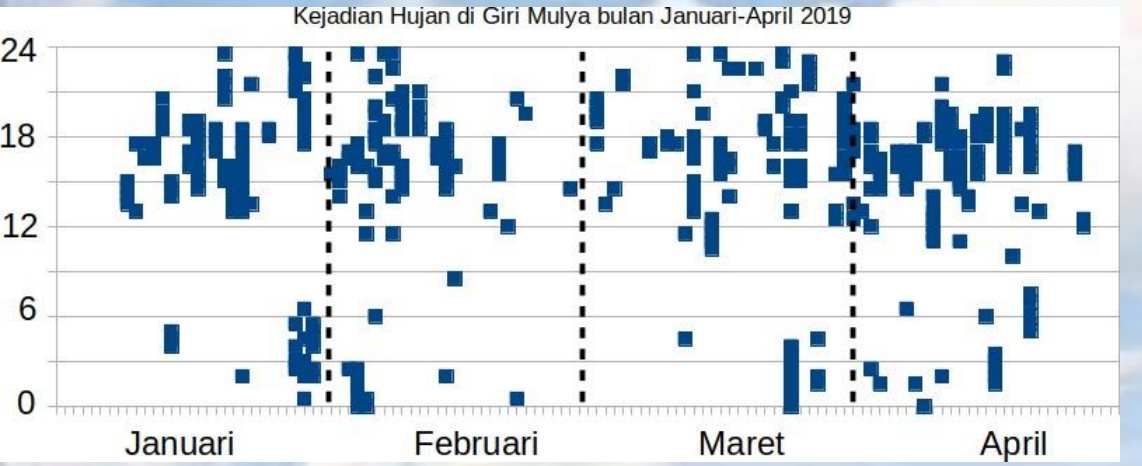


The seeding material used was a mixed between hygroscopic materials and flammable solvents.

The above diagram shows seeding materials usage from the period of 1 January – 31 March 2019 with a total seeding materia usage of **44.970 litres.**



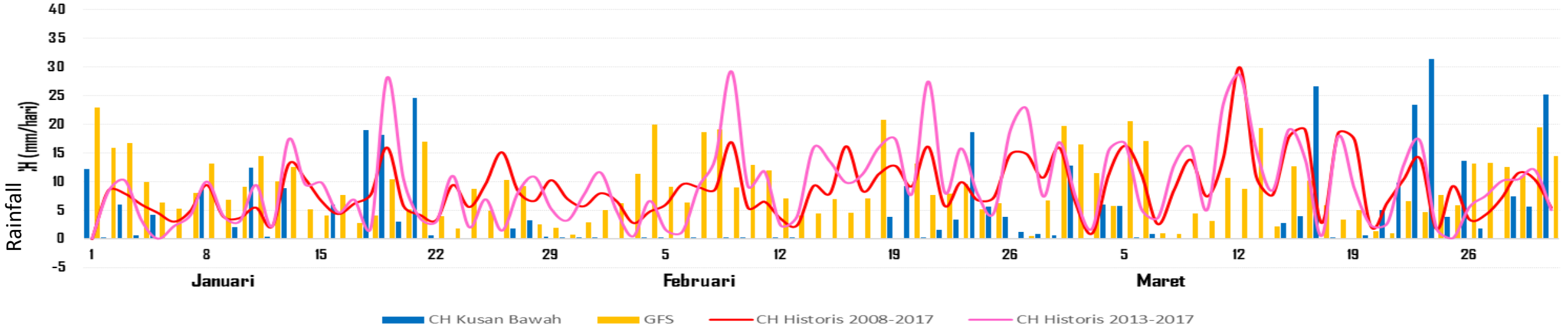




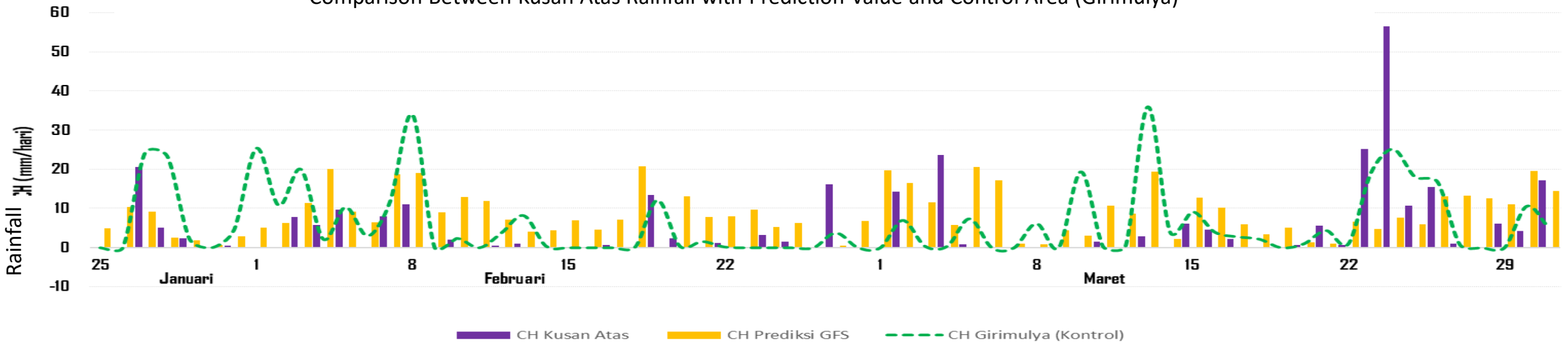
In total during the months of January-March, there are 59 rain days in Kusan Bawah, 43 rain days in Kusan Atas (January was counted from the 25th) and 65 rain days in Giri Mulya, with the average rain durations each being 3.37, 3.03 and 3.40 hours/day.

Research Experiment Result Analysis (Rainfall Amount)

Comparison Between Kusan Bawah, GFS, 2008-2017 Historical Rainfall and 2013-2017 Historical Rainfall



Comparison Between Kusan Atas Rainfall with Prediction Value and Control Area (Girimulya)

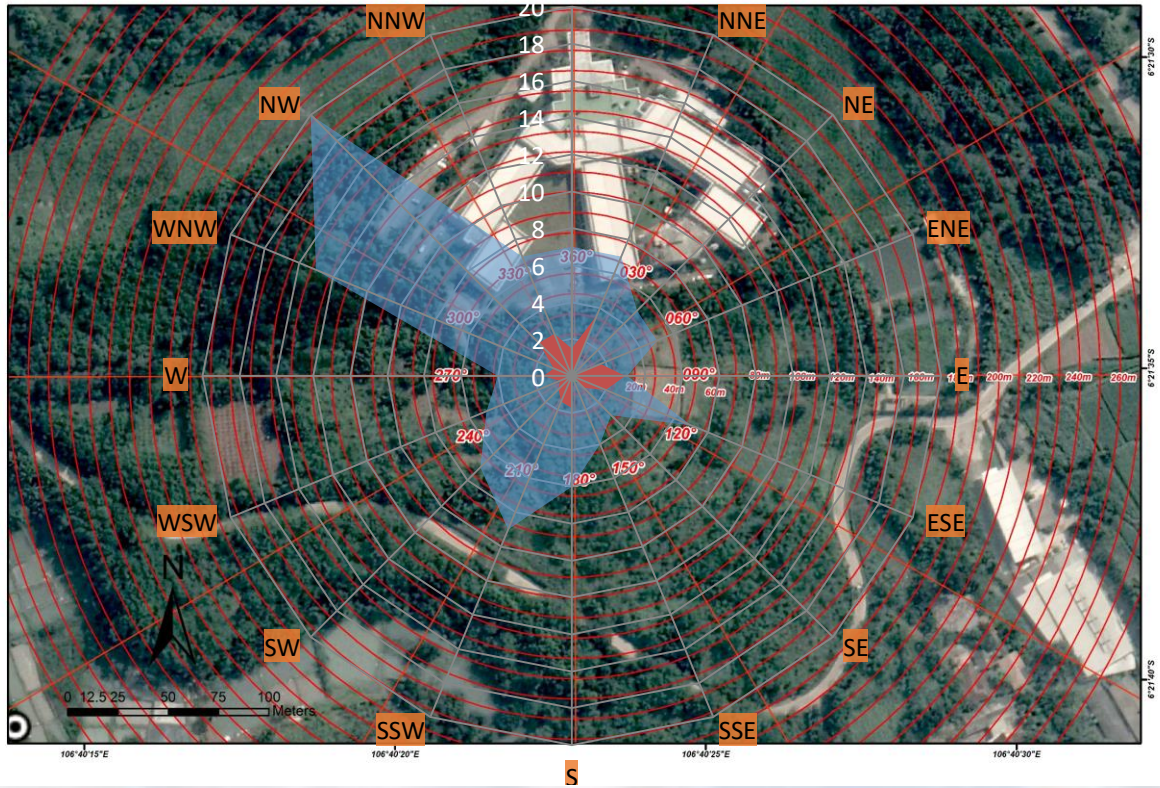


Research Experiment Result Analysis (Particle produced from the generator)

GROUND

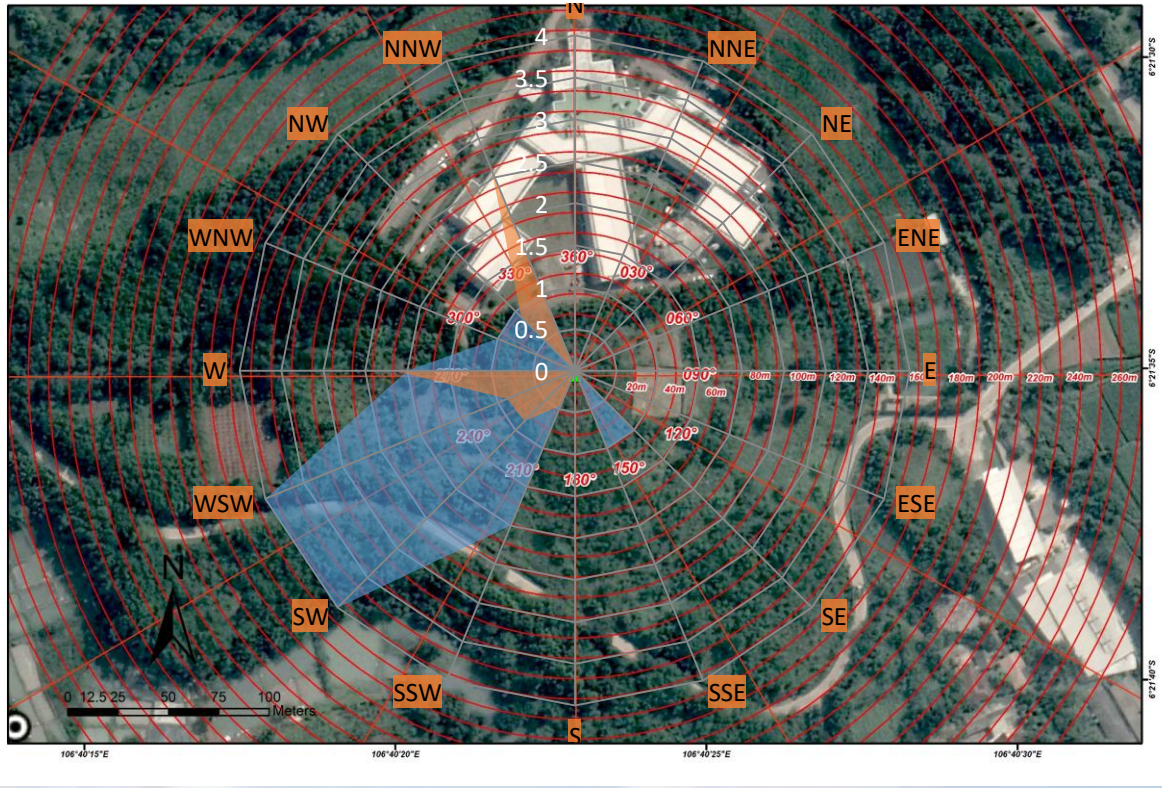
Meteorological Data (Wind Rose Data)

Working Plan Map of GPG Testing in Geostech Area, Serpong, Indonesia



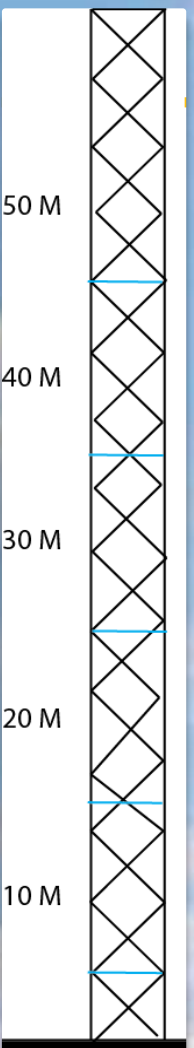
Heading and Wind Speed 5 (07.00 WIB) - 9 (12:00 WIB) Nov. 2018. WIB = Western Indonesian Time.

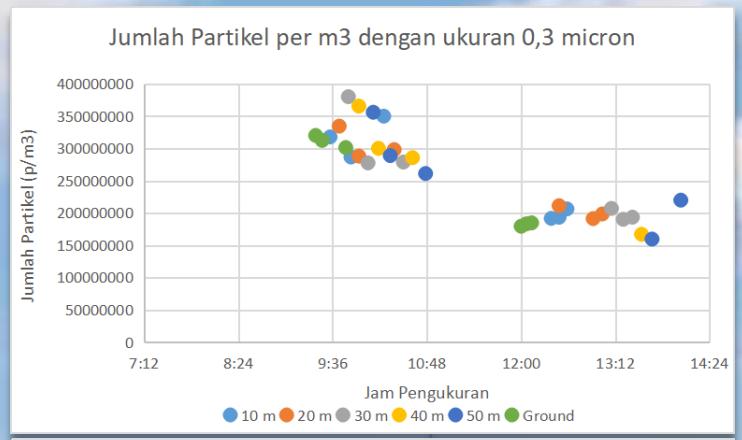
Working Plan Map of GPG Testing in Geostech Area, Serpong, Indonesia

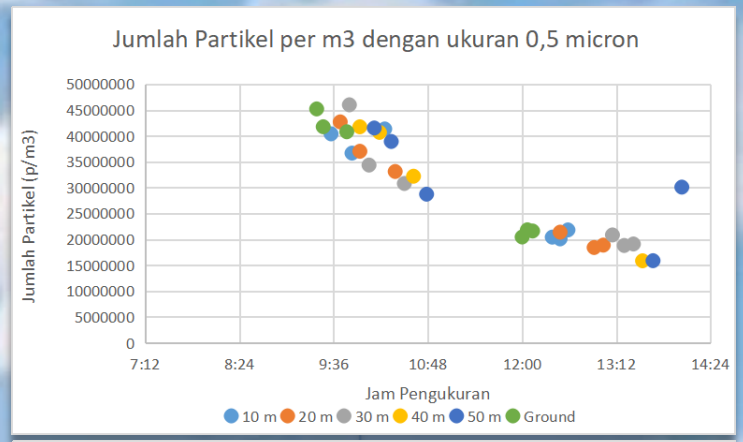


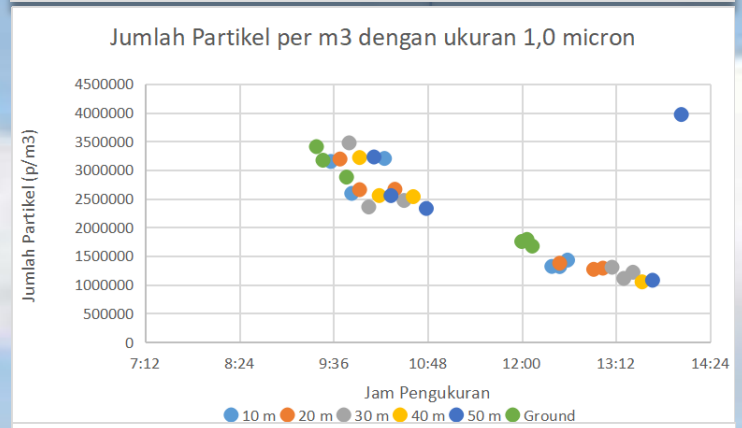
Heading and Wind Speed 5 - 9 (07:00 - 10:00 WIB) Nov. 2018.

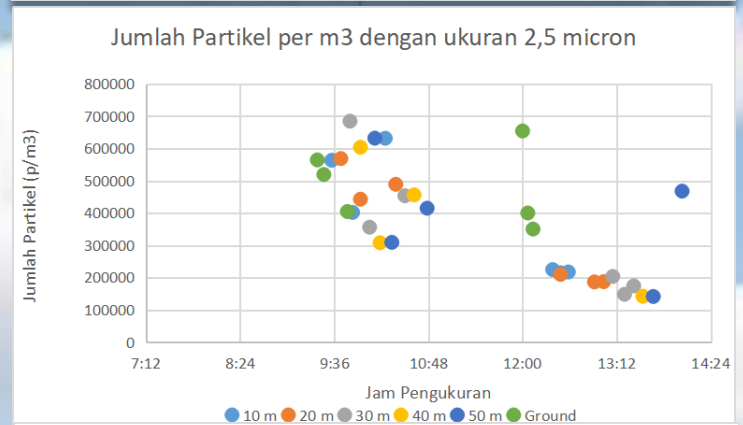
Background Particle Measurement

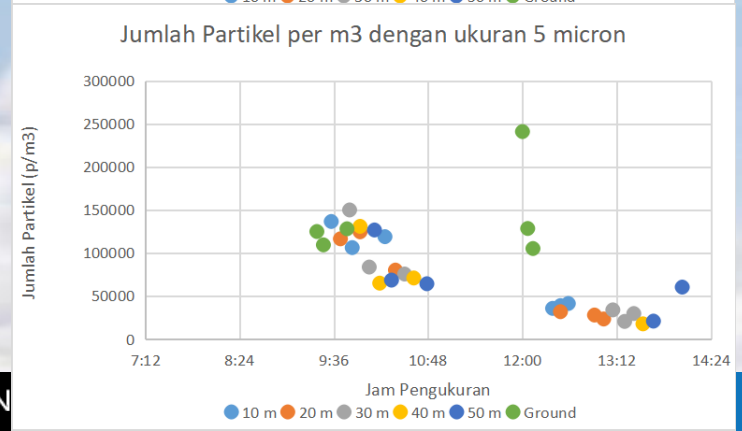


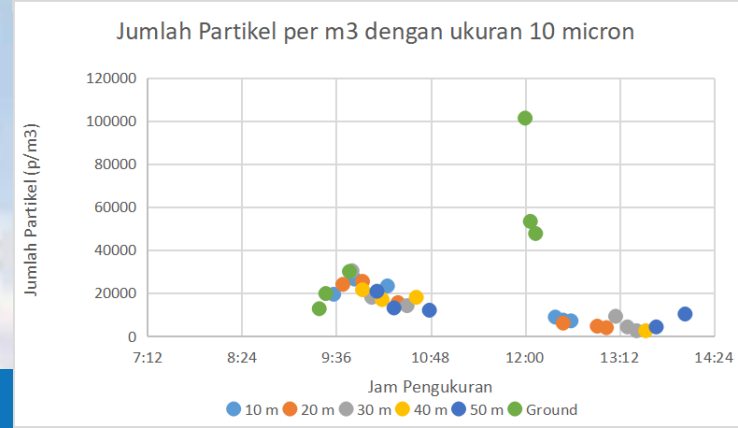






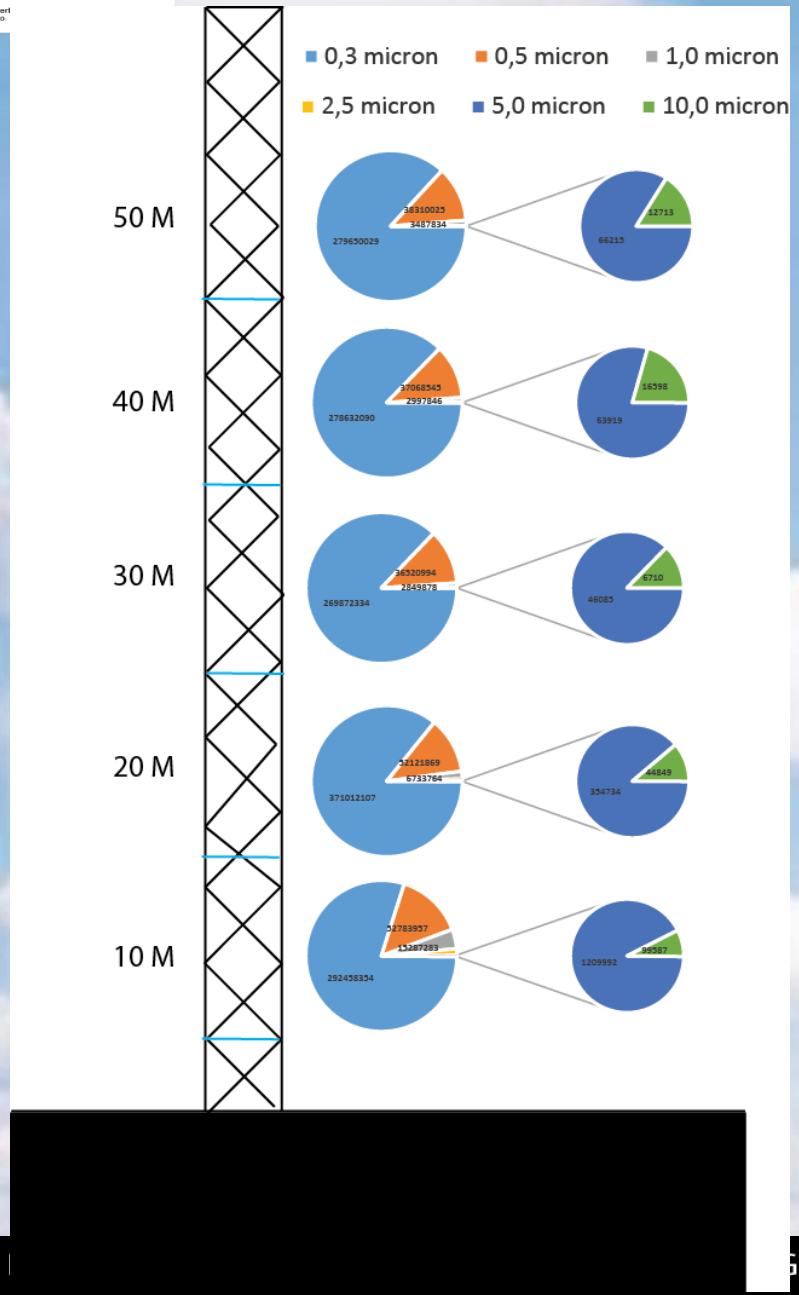


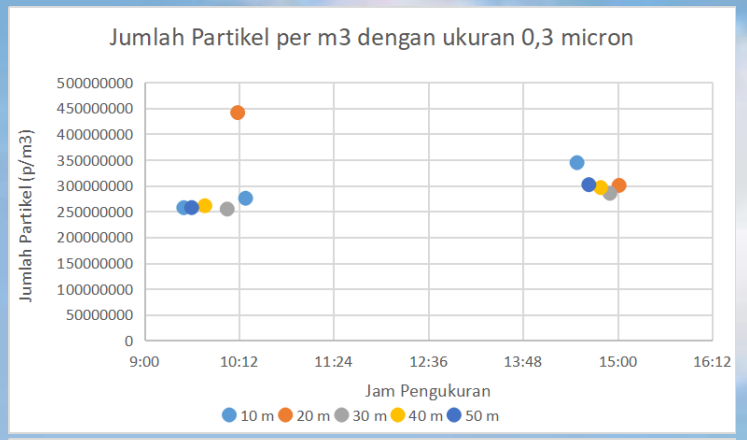


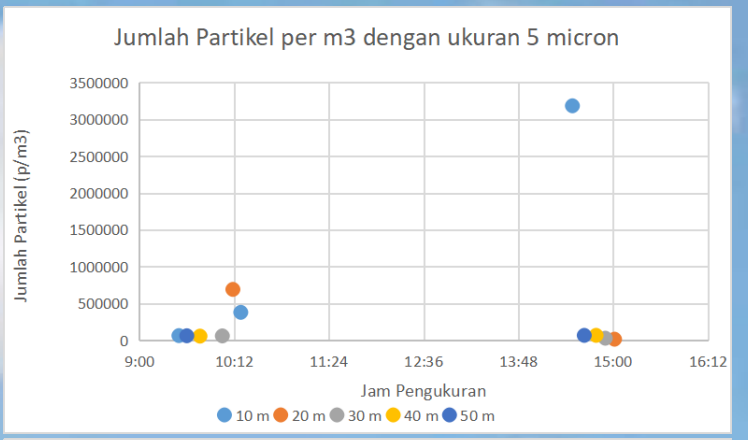


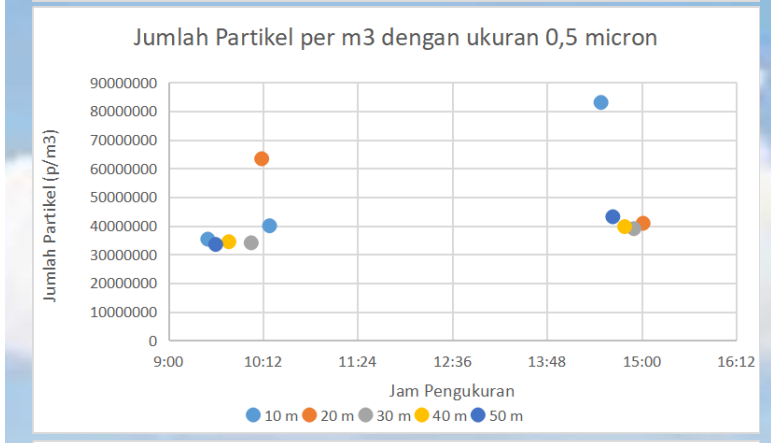
Jumlah partikel/m^3

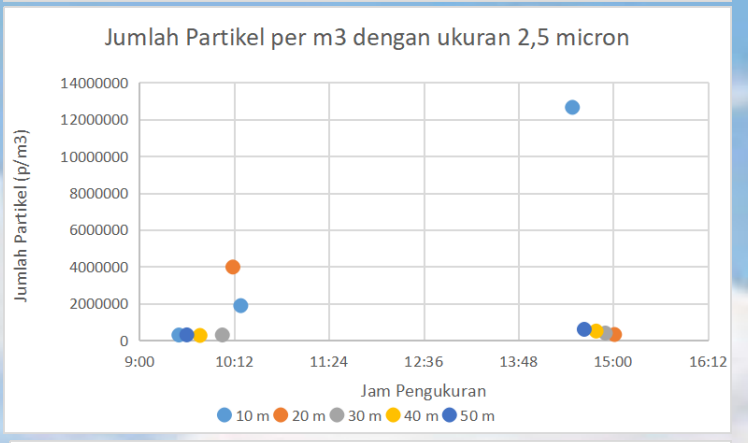
GPG Particle Measurement

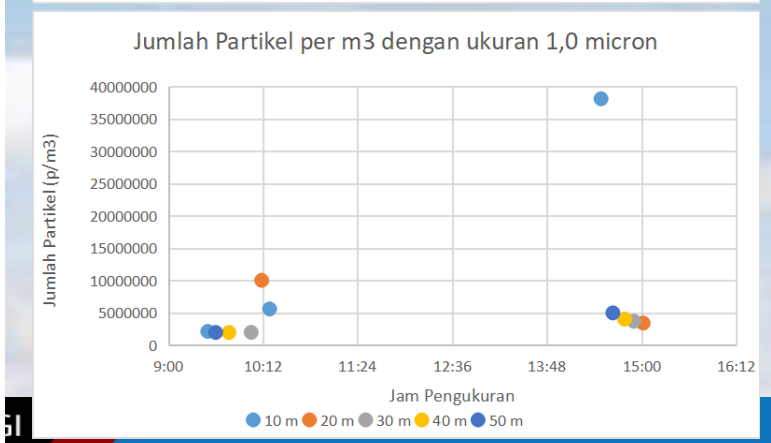


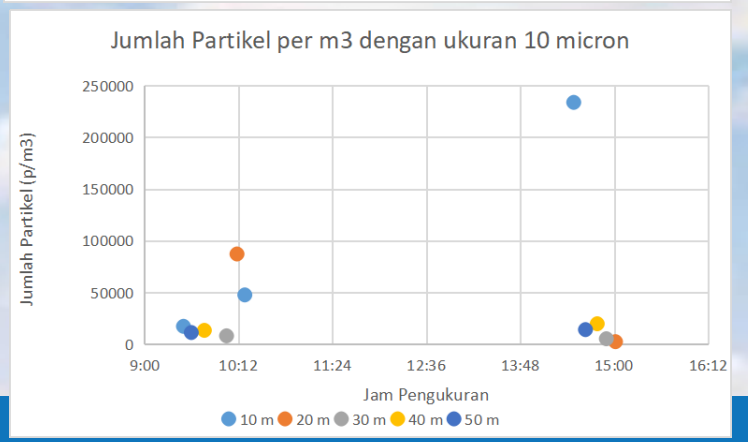




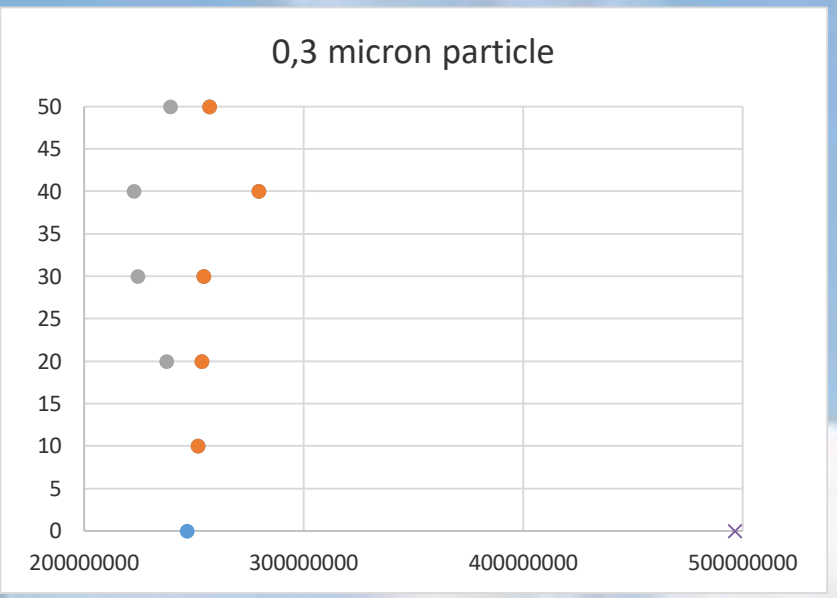


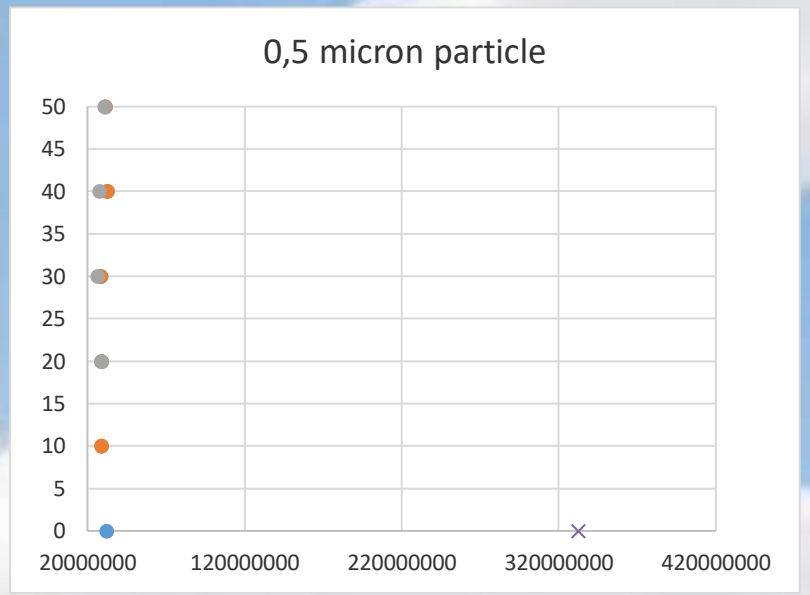


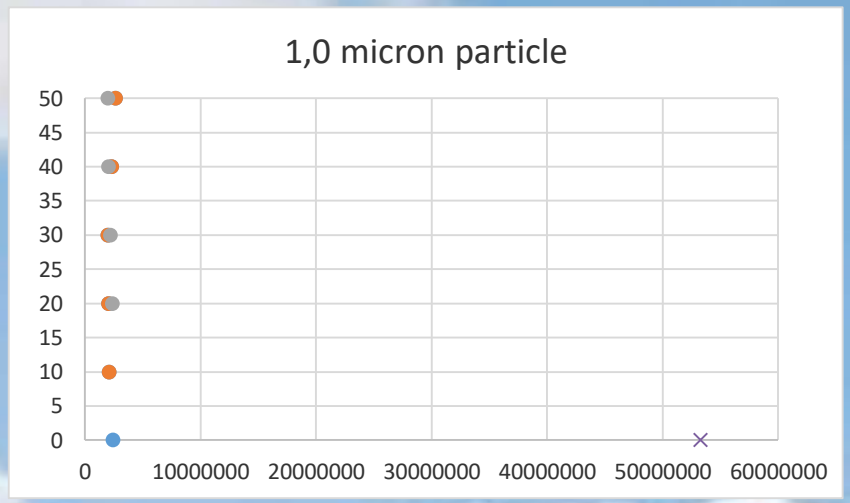


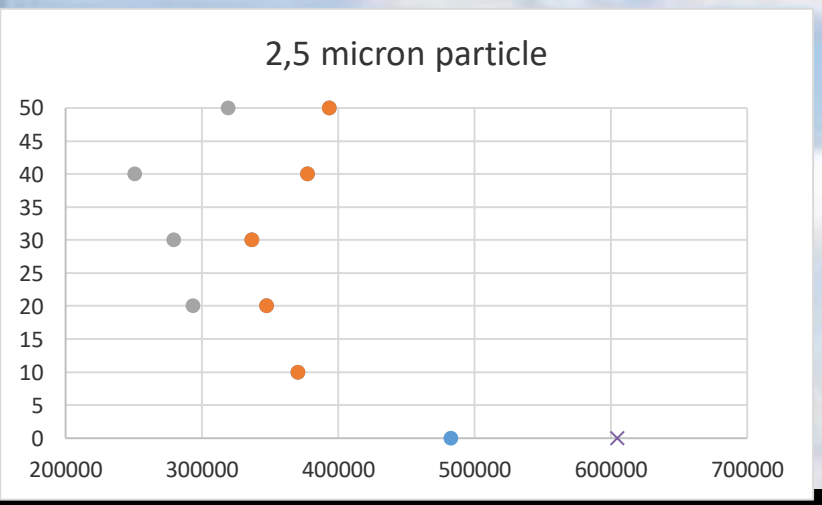


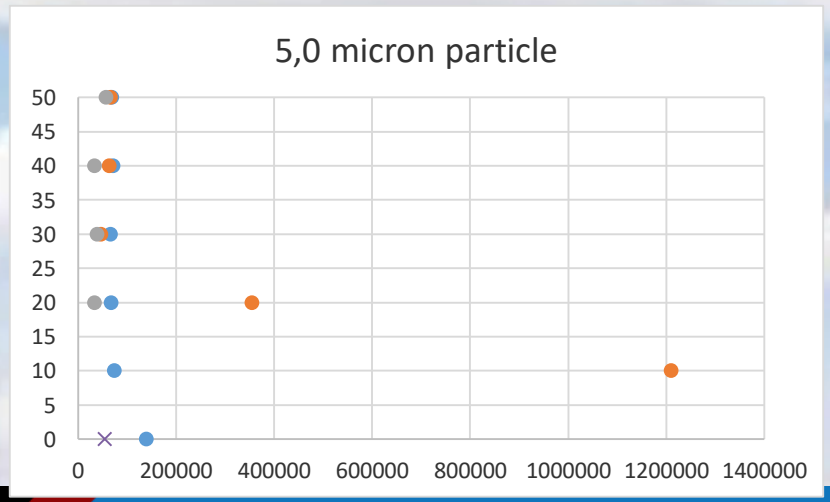
Particle Distribution per height and at source

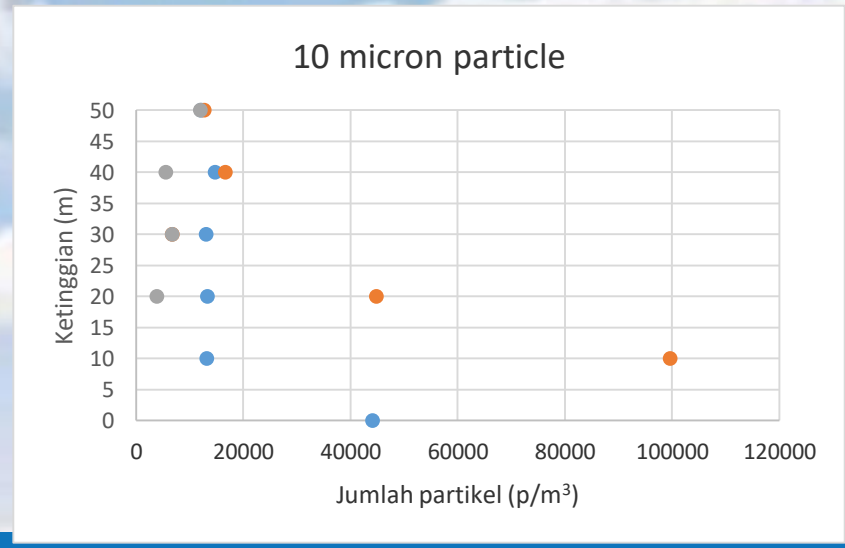






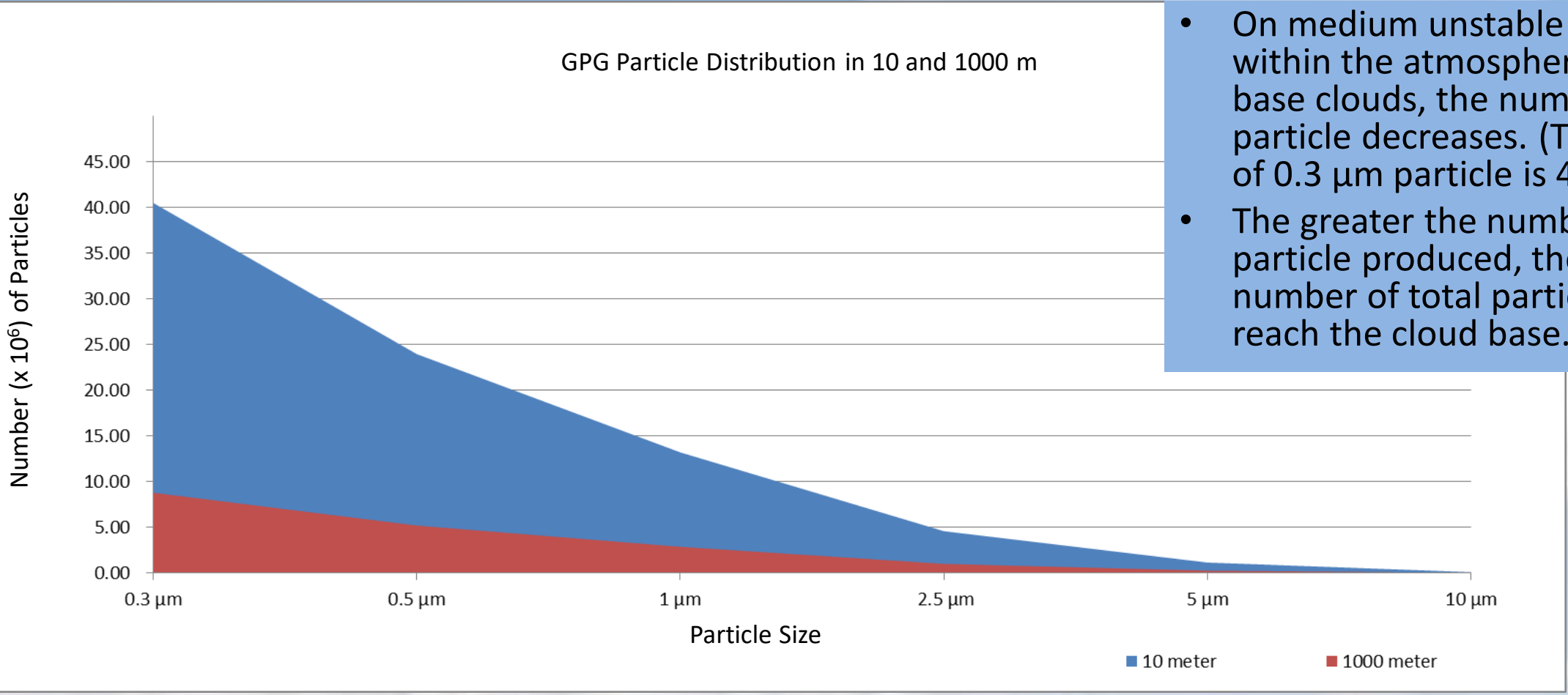






Gaussian Dispersion model (vertical distribution)

**Ongoing research*



- On medium unstable conditions within the atmosphere, nearer to the base clouds, the number of GPG particle decreases. (The total number of 0.3 µm particle is 40 million).
- The greater the number of GPG particle produced, the lesser the number of total particle that would reach the cloud base.

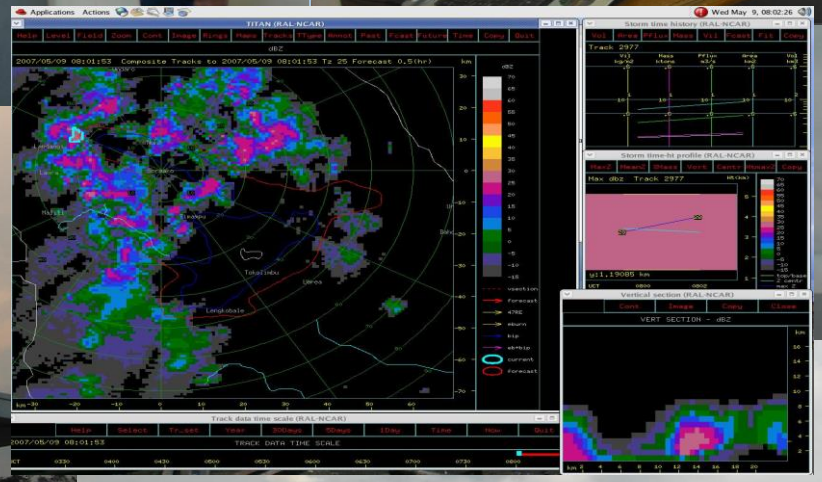
Rain Enhancement Project Using Ground Base Generator In Indonesia .

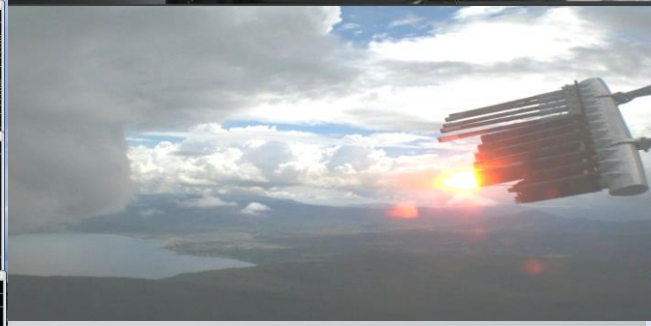
Case Study: Nickel Mining Area

WMT at Sorowako, South Sulawesi Indonesia

C-band Doppler Radar

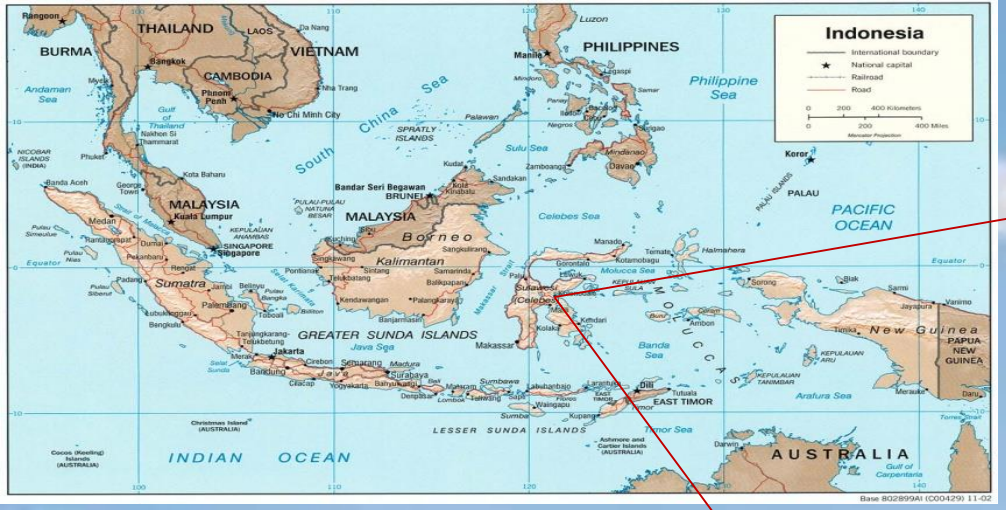
Operations Center

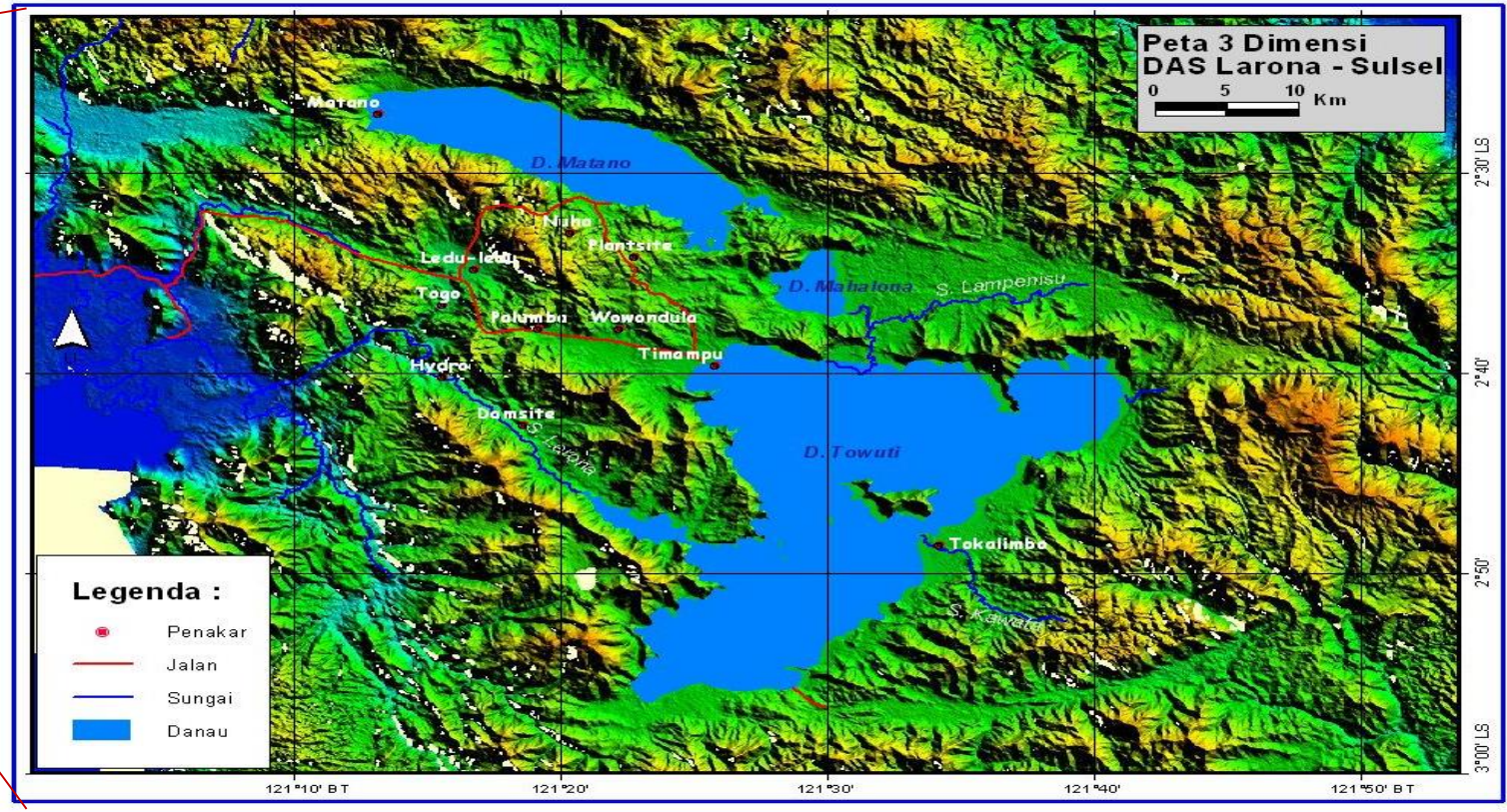




Seeding Aircraft

Map of Larona Catchment Area





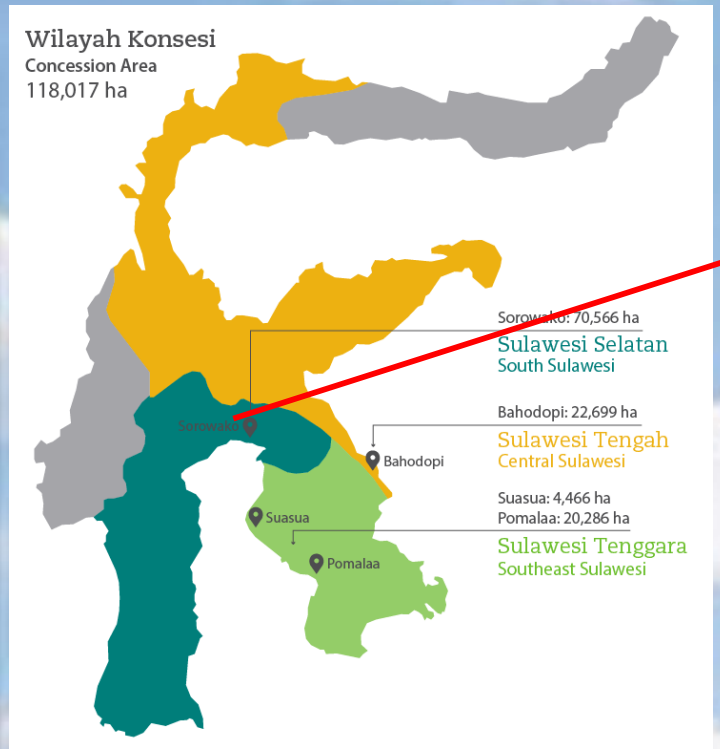
The total area of Larona Catchments Area, as the target area for cloud seeding program, is of about 2,477 km^2. There are three lakes in the Larona, namely Matano, Mahalona and Towuti that feed the two power stations at Larona and Balambano.

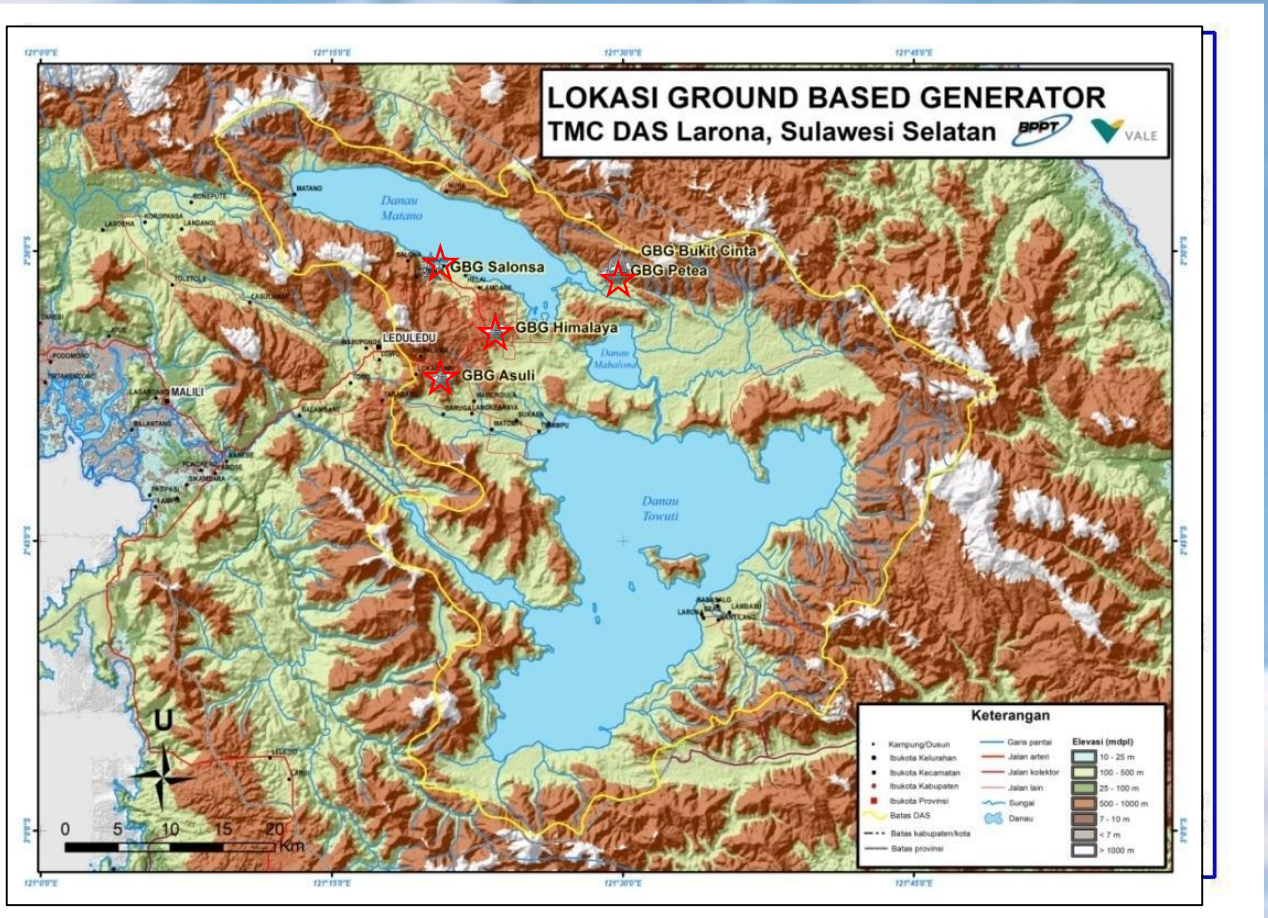
hygroscopic flares

- 1 kg material
- 12 on each wing
- Seed at cloud base.

Rain Enhancement using GBG

Location





1. Bukit Asuli (121.3450ₒBT, 2.60633ₒLS, 773 mdpl).
2. Salonsa (121.33510 ₒBT, 2.51267 ₒLS, 476 mdpl).
3. Bukit Cinta (121.49920 ₒBT, 2.51117 ₒLS, 804 mdpl).
4. Bukit Himalaya (121.39120 ₒBT, 2.56483 ₒLS, 635 mdpl)
5. Petea (121.4899 ₒBT, 2.51560 ₒLS, 500 mdpl).

LARONA CATHMENT AREA

Hygroscopic Flare Loading

GBG Burning at Salonsa

GBG at Bukit Cinta

GBG Burning at Bukit Cinta

GBG Instrumentation

GBG Burning at Bukit Himalaya

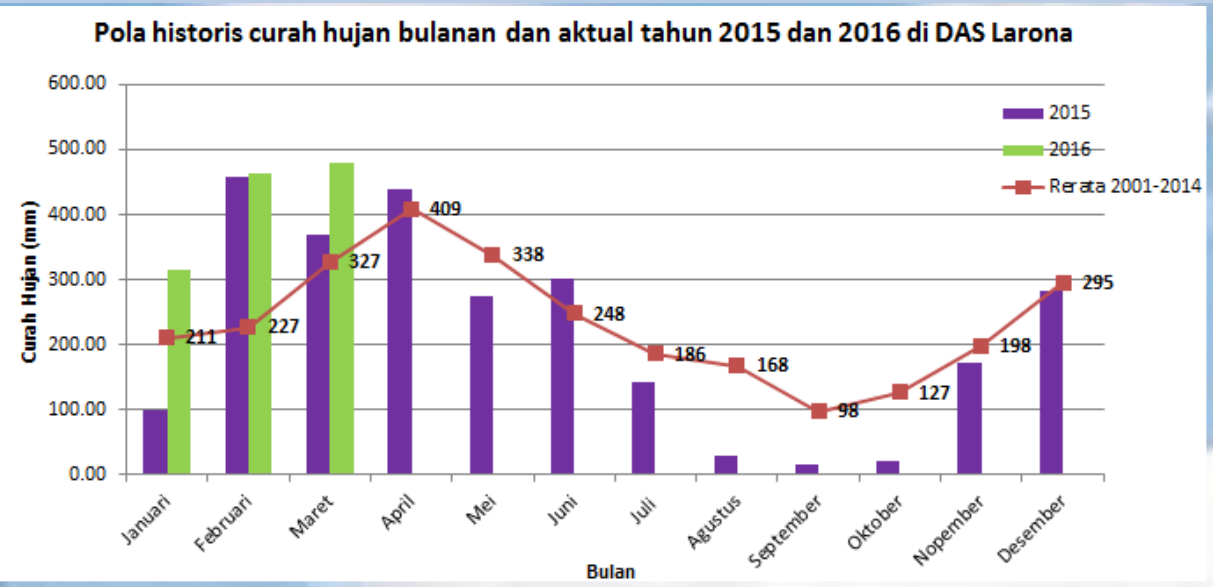
GBG Tower covered by Fog

Rain occurrence over the Lake (27-02-2016)

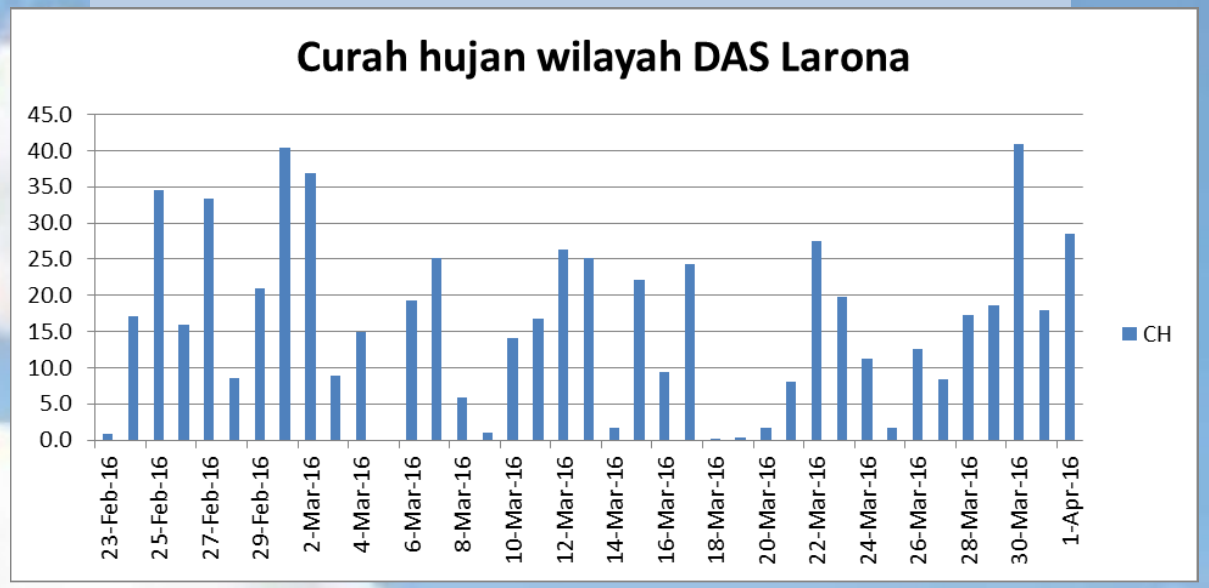
Hygroscopic Flare Loading

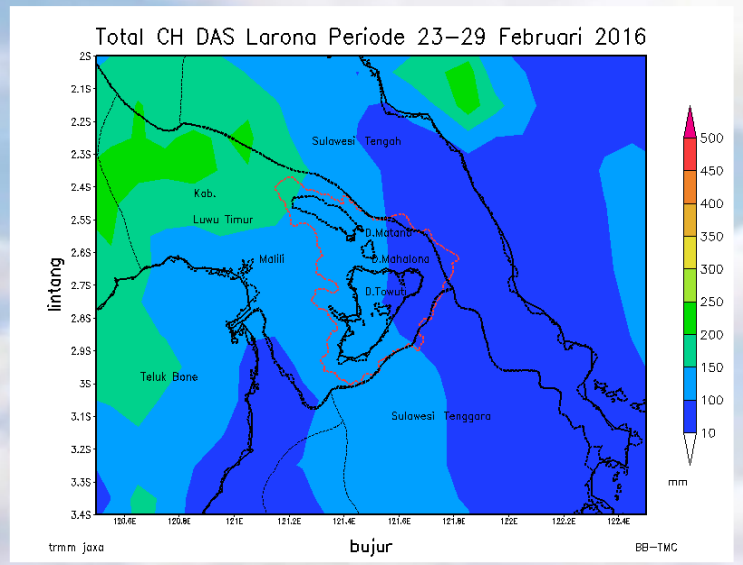
Flare Warehouse

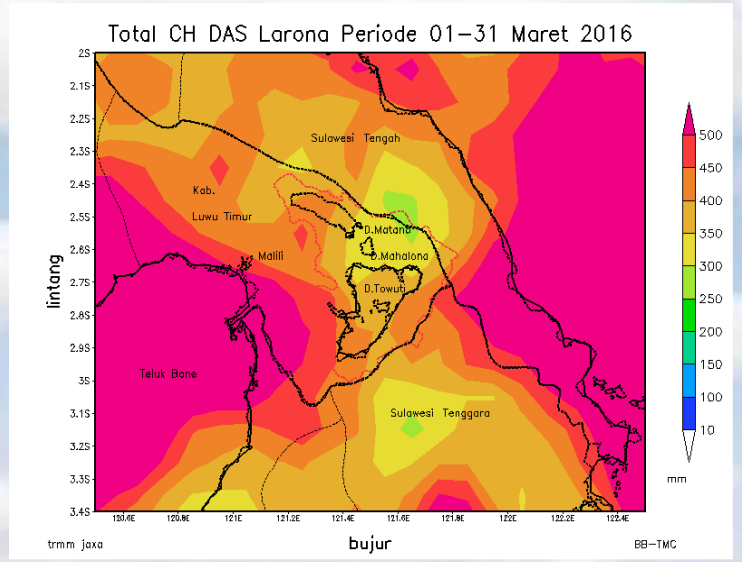
Monthly Rainfall amount in 2015, 2016 and average during 2001 - 2014

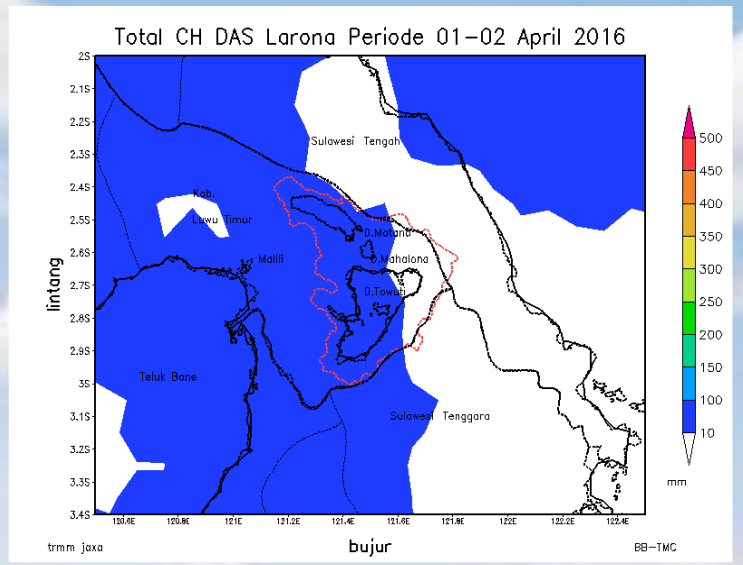


Daily rainfall amount during GBG Operation (mm/day)

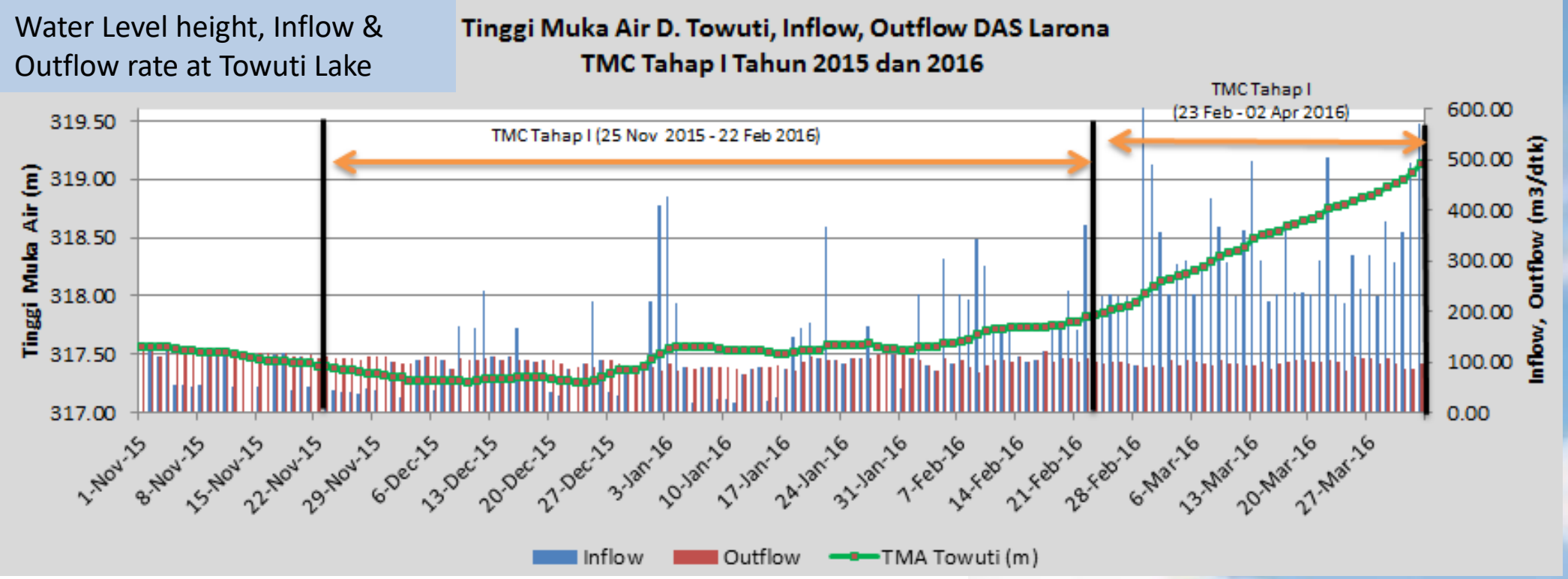


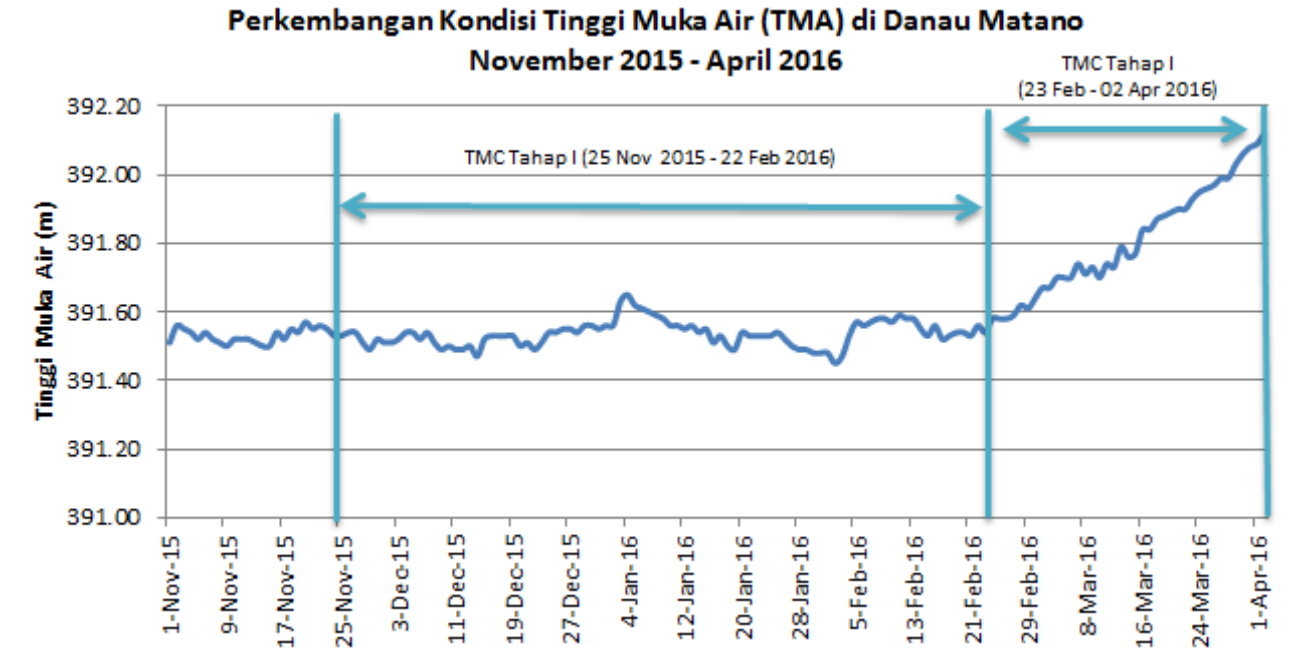






Water Level height, Inflow & Outflow rate at Towuti Lake





Water Level height at Matano Lake

THANK YOU

Badan Pengkajian dan Penerapan Teknologi