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Weather Modification for Rain Reduction - A Conceptual Design

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1. Introduction

Weather modification technology has been utilized not only for rain enhancement, but also for hail suppression, fog clearing and rainfall intensity reduction. Weather Modification Technology Center carried out experiments in rain intensity reduction in order to overcome floods via competition method in Tuntang area – Central Java during the rainy season of 1995. The result showed that rainfall intensity was decreased to about 15 %. In addition, we had carried out rainfall intensity reduction over The Jakarta area in February 2002. It was considered successful even for only about one week time. The operation was stopped because the adjacent districts complains due to rain occuring more in their areas. This operation is conducted by the jumping process utilization.

Along with more advance research on weather modification technology with the purpose of decreasing rainfall intensity, some countries, such as PRO China and Russia have applied this technology to prevent rain occurrence during some events. Russia has utilized this technology during open door state events, while PRO China applied this technology in Beijing during the opening ceremony of 2008 Olympiad.

The need for weather modification in the form of rain reduction in Indonesia is very high. Open coal mining companies, many located in Kalimantan, require so much of this technology in order to increase its production. Some coal companies which has expressed its interest on using this technology, for instance is PT Adaro Indonesia.

PT. Adaro Indonesia own an open coal mining in South Kalimantan. Its production is influenced by rain occurrence within the mining area. If rain falls, mining activities will be stopped until the top soil is dried and slip free. It may take a while, few hours to days, for it to dry itself. Therefore, It has the potential of reducing PT. Adaro Indonesia coal production. Such events would often occurs during the rainy season. Steady rain from stratiform clouds will even worsened the situation. Stratiform clouds developed mostly in a stable atmosphere, this kind of clouds has a large coverage, produces light rain and may cause overcast. Therefore, the solar radiation needed to dried the slippery soil is also reduced. In order to minimize lost opprotunity due to rain occurrence, PT. Adaro Indonesia consulted the Weather Modification Technology Center (WMTC) to inquire whether the WMTC could help them to alleviate their problem.

The other coal mining companies which has shown interest with this technology is PT Pama Persada. Problems arising in PT Pama Persada is not so much different with those of PT Adaro Indonesia. The same could also be said with regards to other open coal mining estabilishments.

Beside coal mining companies, Provincial Government of Central Java has lately expressed its interest in this technology. Rain reduction weather modification is meant to be used to prevent the occurence of heavy flood on the top of Mount Merapi in Central Java which if happens, will spew out 14 million m3 cold lava which would be disastrous to the surrounding area inhabitants.

This paper is a theoretical review of weather modification for rain reduction and the example of its planned application in PT Adaro Indonesia.

2. Weather Modification Technology for Rain Reduction

Studies on rain intensity reduction has been done by many scientists. These studies have been done 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.

Competition Mechanism

In a precipitating cloud, precipitation developed when the cloud droplet population become unstable, and also when some droplets grow at the expense of others. The mechanism whereby a cloud microstructure may become unstable involves direct collision and coalescence of water droplet. The most important event for a precipitating cloud is the collision event. In its earliest stage, a cloud is an assembly of tiny droplets numbering in the order of 100 /cm^3 and having radii of about 10 µm. Because efficiency of collision and coalecence is very low (figure 1), this structure is of course extremely stable.

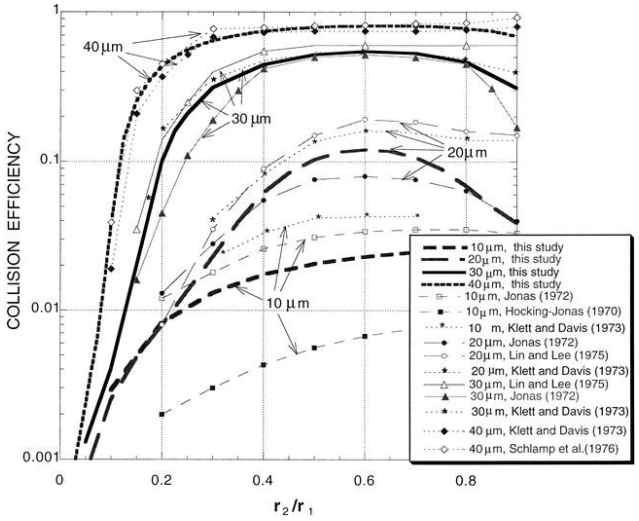

Figure 1. Efficiency of collision and coalesence (Pinsky et.al., 2000).

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. To conduct the operation, Piper Cheyenne will be utilized to deliver seeding agents in the form of flares. This action would then prevent collision process because within the clouds exists cloud droplets homogenic in size. Once larger droplets are present, collision – coalescence chain reaction would then started.

The best example of competition mechanism is during forest fires events. Because there are too many aerosol present, which have sizes less than 1 µm, produced by forest fires, cumulus clouds barely developed over the fires and vicinity areas.

Jumping Process Mechanism

Collision efficiency intensifies drastically when cloud droplets grew. Collision efficiency of 10% for droplets size of about 10 µm in radii increases drastically to 80% when the droplets size is about 30 µm in radii (Pinsky et al., 2000, see figure 1). The Jumping Process Mechanism is initiated by introducing large hygroscopic seeding agents of about 10 – 100 µm in size into clouds to increase collision efficiency so that rain may occur shortly. It is noted that 10 µm of hygroscopic seeding agents would create more than 30 µm droplets inside the clouds. This mechanism will then be applied to developing clouds that posses the possibilities to produce rain over the entire target area. This activity had been performed during cloud seeding activity to enhance rainfall over small target area.

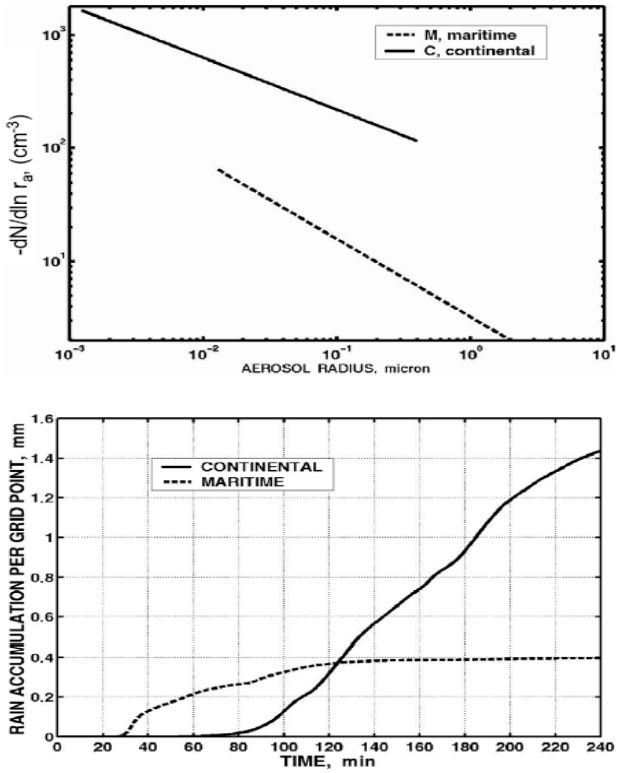

Figure 2. Features of Maritime and continent clouds (Khain et.al., 2005).

Features of Maritime cloud and Continent cloud (Khain et.al., 2005, see figure 2) are:

Maritime Cloud:

- Big aerosol (CCN) size but smaller amount
- Weak updraft
- High moisture
- Quick to rain
- Small rainfall amount

Continent cloud:

- Small aerosol (CCN) size but larger amount
- Strong updraft
- Low moisture
- Slow to rain
- Large rainfall amount

These features agreed well with Pinsky et.al., 2000 in which big aerosol correlates to the acceleration of rain process. Bruintjes et.al., (private communication, 2004) showed that ultra giant aerosol (more than 10 µm in radii) may bypass the CCN population action in determining the initial character of the cloud droplet population, and thus, jumpstart the coalescence process itself.

3. Application of Weather Modification for Rain Reduction

In the application of weather modification technology for PT. Adaro Indonesia, the WMTC will carry out some methods, of how to apply weather modification technology (WMT) and how to evaluate weather modification activities. In response to enquiries, the WMTC conducted field survey in order to study December 2010 cloud formation. Some notes from the survey might be summarized as follows:

1. The present cloud formation seems to be of a typical land cloud formation. In early morning there were stratiform clouds, which then broke up in late morning. Cumulus clouds develop mostly in early afternoon and rain falls in late afternoon.
2. Surface winds were mostly westerly during daylight hours in the rainy season, while during the night time winds were mostly south easterly. Surface wind speeds were mostly about 5 knots.
3. Mining was stopped when rain occurs. The reason is that the top soil during and after rainfall becomes very slippery. The activity would then resume when this slippery condition is no longer present. Therefore, the duration lost due to rain may be calculated as rain duration plus the period needed to dry out the top soil. From data analysis, it could be concluded that the monthly average of lost time as: 140,60 hours in January, 110,92 hours in February, 135,07 hours in March, 128,82 hours in April, 80,46 hours in May, 74,04 hours in June, 59,02 hours in July, 38,02 hours in August, 44,42 hours in September, 60,82 hours in October, 120,83 hours in November and 150,77 hours in December.

In carrying out those two mechanisms, several strategies are applied ;

1. During the early stage of cloud formation, competition mechanism will be initiated by introducing very fine seeding agents of flares by Piper cheyenne aircraft. This would then add more small droplets so that the collision efficiency remains low. As a result, cloud development would become very slow.
2. When there are potential clouds, jumping process mechanism would then be initiated. This is to force rain to occur before it reaches the target area. Therefore, this activity will be done mostly in the upwind area. In order to carried out the jumping process CASA NC 212-200 will be used to deliver seeding agents in powder form.
3. When the water vapor supply is too high and the competition mechanism is no longer sufficient to slow down cloud development, jumping process would then be initiated using CASA NC 212-200. This is done to shorten rain duration. This strategy will also be used when weather condition allow the presence of thick stratiform clouds that may cause longer period light rain.
4. As aircraft would only be flown in daylight, ground base generator will be utilized to start the competition mechanism if needed during night time. For this purpose, four (4) ground base generators will be installed around the target area. However, ground base generators will not be used for the upcoming activity because realization plans for the ground generators still needed to be finalized.

For services to PT. Adaro Indonesia, the WMTC will execute 2 mechanisms in order to reduce rainfall intensity and or rain occurrence over the mining area.

Weather Modification Activities

Weather modification activities will be carried out day and night. During daylight, 2 aircrafts, CASA NC 212-200 and Piper Cheyenne, will be used for weather modification activities. CASA NC 212-200 is used to carry seeding agents in powder form to execute the jumping process. While Piper Cheyenne will be used for seeding agents in pyrotechnics form (flares) to execute the competition mechanism. Flight activities will be guided by flight scientists in executing strategies based on weather data analysis.

During night time, weather modification activities will be carried out through ground base generator. Ground base generator is employed to introduce super fine particles to initiate the competition processes. Operational design of this technology is shown by figure 3.

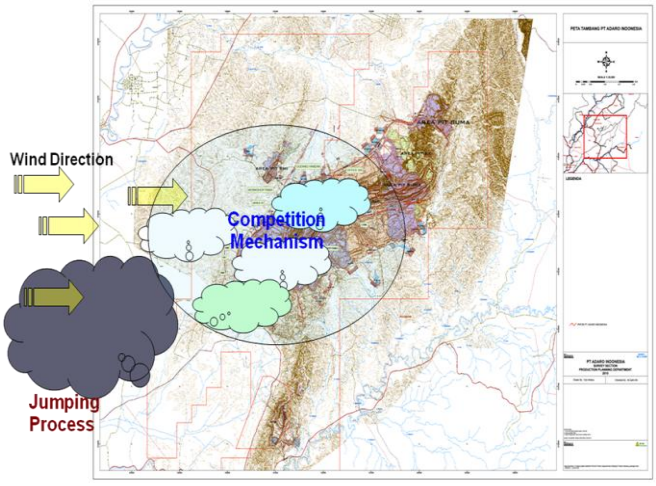

Figure 3. Operational design of weather modification technology for rain reduction at PT Adaro.

4. Summary

1. The need for weather modification technology in the form of rain reduction in Indonesia is very high. Aside from its use in disaster prevention, this technology is very economical as well.
2. Weather modification technology may be applied to reduce rainfall using the competition mechanism and jumping process mechanism.
3. Based on researches and experiences on rainfall reduction, weather modification technology is able to reduce about 15 – 30% of rainfall. By utilizing competition mechanism and jumping process, it is posibble tor reduce more than 15-30% of rainfall.
4. Weather modification activities should be carried out for longer period considering that the possibility of cloud formations is unpredictable. The WMTC suggests that weather modification activities are carried out during rainy season in the area.

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