Long Range Transport of Air Pollution from Biomass Open Burning in High-elevated Area to Chiang Rai Province

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Abstract*— *Chiang Rai is the northernmost province in Thailand, adjacent to neighboring countries such as Myanmar and Laos. The open burnings for land preparation in an elevated area, especially for Maize plantation in March to April every year, released a large amount of air pollutants, and cause serious effects on the air quality, public health and climate. In this study, the number of hotspots, which represents open fires, was counted and detected by MODIS imagery. The high hotspots density are found in the west of Chiang Rai, where are mountainous, high-elevated and mainly used for maize cultivation. Using HYSPLIT4 Model, the backward trajectories, moved across the south to west, were frequently occurred and analyzed. Consequently, the smoke haze was influenced by the upwind regions. Therefore, the solution for smoke-and-haze problem needs to be conducted with the land utilization. The haze started in Thailand and moved to Lower Mekong countries, the dust spread over the area with the wind directions for thousands of miles. For the sustainable solution, people need to focus on land use by changing from annual crops plantation to other permanent crops such as rubber or coffee, which not only help reducing burnings activities but also maintain the sustainability of the natural resources and environment.

***Keywords*— Hotspots, HYSPLIT, long range, smoke haze problem.**

1. INTRODUCTION

Due to the Smoke haze problem that covered all areas of northern Thailand. This has a direct impact on air quality in many parts of northern Thailand, affecting the health of the community. Chiang Rai is one of the provinces affected by these air pollutants. The main causes are wildfire, open burnings for land preparation, and pollution from vehicles using [1] and also from the industry [2]. It was found that the amount of dust or small PM_{10} (Particular Matter less than 10 microns (micrometers) in diameter: PM_{10}) with 50-70 percent of the origin of forest fires and burning of agricultural land, as well as burning in open spaces. And about 10% of the diesel engine, the rest is dust from other sources. Wildfire and burning in the open air cause smog and dust to stay in the atmosphere. Small amounts of dust with a diameter not exceeding 10 μm or PM_{10} (Particular Matter less than 10 microns (micrometers) in diameter: PM_{10}) Small dust particles cause irritation or blurred vision and uncomfortable breathing. In addition, air pollution also affects the business sector. The number of visitors decreased during Chiang Mai's air pollution and the haze crisis. The damage to the economy is very significant [3].

Chiang Rai is the northernmost province in Thailand, adjacent to neighboring countries such as Myanmar and Laos, where it is found burning in the dry season. It is during February to April every year, especially in March every year [4]. As the sequence, Chiang Rai has the opportunity to face the problem of cross-border haze [4],[5],[6].

Because Chiang Rai province is a mountainous terrain, there are many rivers flowing and based on agribusiness. Most people settled on the flat and also do high space cultivated crops include rice, maize, beans and others, with 35.40% of the total area are agricultural land [7]. Hunting is always set the fire on as one of the causes of forest fire. The findings from the Chiang Rai Provincial Agricultural Extension Office found that highland farmers preferred to grow rice and maize [8][9].

The method is used to burn weeds after harvest to prepare the area for the next growing season. Burning in the agricultural area on high-elevated area, there is no way to prevent the spread of fire, thus spreading wildfire [9]. The conservation area at the station No. 15 National Parks, Wildlife and Plant Conservation found that burning the fields and hunting for fire was the leading cause of wildfire [9]. According to a report of the Pollution Control Department, the PM_{10} value at Chiang Rai Provincial Office of Natural Resources and Environment, PM_{10} was found to be above the standard of 120 μg / m^3 for 24 hours since February and presented as the highest PM_{10} value. In particular, in 2012, the PM_{10} average March was as high as 262.86 μg / m^3, more than twice as high as the standard. As a result, the air quality index (AQI) is more than 100. The AQI value, which is more than 100, is a level that directly affects the health of people in the area [10] especially vulnerable groups; children under 5 years old and older persons of 60 years and over, as well as respiratory patients. According to the Department of Disease Control No. 10, on March 15, 2007 to March 22, 2007, 57,765 patients were hospitalized in 9 provinces including Chiang Mai, Lamphun, Lampang, Mae Hong Son, Phayao, Chiang Rai, Phrae, Nan and Kanchanaburi. 7,220 cases, more than 90%, are common respiratory illnesses. The highest

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number of patients in Chiang Rai was 18,412, followed by Lamphun 13,936 and Chiang Mai 8,399 [11]. According to Chiang Rai Hospital's Prachanukroh Hospital, there are reportedly in March from 2007 onwards that the average number of patients ever treated is 2,200 per day [11].

Therefore, it is the source of this study that aims to study the pattern of fire in Chiang Rai area. In this project, we use hotspots that appear on satellite images in NASA's MODIS system [12]-[13]. The Hotspot study was conducted in March 2007-2015 (except for 2008, 2011, and 2014), where the Latino phenomenon caused unusually heavy rainfall during March. This is comparative study in order to study the area of surveillance and risk at the community level. Studies on the long-range transport contribution on haze episode, the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT4) model, were conducted to investigate the probability. The probabilities of being affected by cross-border haze are employed. The results of this research will be used to plan the solution to the haze problem at the local and national levels [14].

2. METHODOLOGY

The hotspot pattern

The number of hotspots, which represents open fires, for the heat point data used in this research. It is a technology for detecting spots or areas with very high thermal values on the surface of the Earth (Hotspot) using the thermal sensor (Thermal Sensor) equipment installed on the Earth Observation Satellite (Earth Observation Satellite) Terra and Aqua satellites are used by MODIS to detect heat points. Terra will orbit through Thailand in the morning and Aqua will orbit through Thailand in the afternoon [12].

Presenting in FIRMS webmapper http://firefly.geog.umd.edu/firms/, This is the most likely source of information close to the Real Time Data [12]. NASA will detect or adjust (Refresh) data every two hours [13].

It is necessary to create a spatial database for the data which are monthly, especially in March, 2007-2015 (except for 2008, 2011, and 2014 and yearly grouped for Chiang Rai Province. The process of database development was conducted using the Geographic Information System (GIS) tools.

Analyzing long-range transport

For analyzing long-range transport contribution on haze episode, the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT4) model, is available at http://www.arl.noaa.gov/ready/hysplit4.html [14], was used. This online tool calculates the backward trajectories from the PM_{10} monitoring station. The output could be used to roughly represent the travel pathways of smoke from the origin of open burning. The model was run by using the “Final Run” meteorological data archives (FNL) of the Air Resource Laboratory, National Oceanic and Atmospheric Administration, USA. In principle, the HYSPLIT model is used for long-range transport study and the starting level should be in the free atmosphere. For this research, the starting time was selected at 12:00 am Thailand Local Standard Time, taking into account that the people normally burn during 10:00-14:00, and total run time was about 24 hours [15].

3. STUDY AREA

Chiang Rai locates at 19o 20 / 30.89 / N and 99o 49/57 / E. From the north boundary to the city, it started from Doi Tachilek, Shan State, and Republic of the Union of Myanmar to the south of Thailand. On the northeastern, the area contacts with the Mekong River. The eastern border contacts Luang Prabang, which is the border of the Lao People's Democratic Republic, then ended south at Phayao. The southern part is connected with Phayao, Lampang and Chiang Mai. The western part is connected with Chiang Mai (Figure 1).

Fig 1: Phayao, Lampang and Chiang Mai where the Western Part is connected.

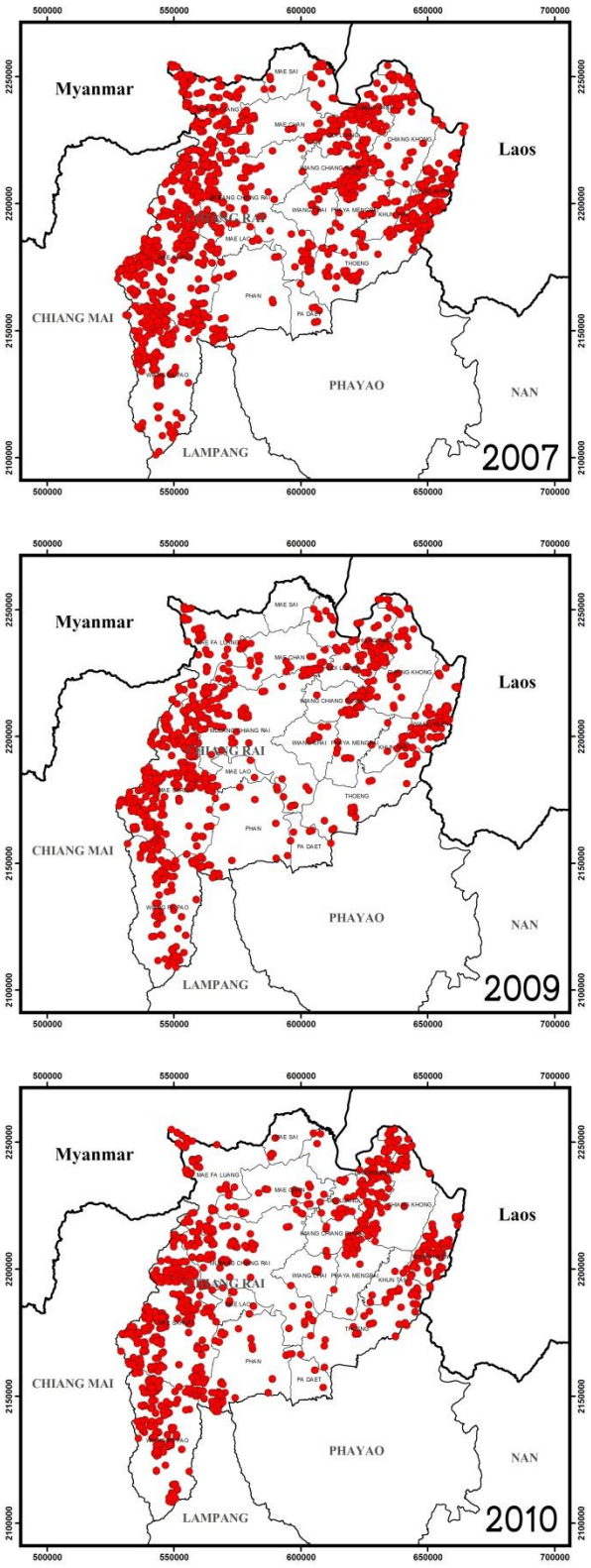
4. RESULT AND DISCUSSION

The hotspot pattern

The study found that the number Hotspot occurred in March of each year. The most common were in 2012, 2010,2009, 2013 and 2015, respectively, with the following hotspots: 2603, 2479, 1838, 1692, 1227 and 964.

It is also noted that hotspots are the most hotspot in many areas and the high numbers of hotspots in the high density of hotspots are located in the western part of Chiang Rai (Figure 2). In the district on the west, such as

Vientiane, Mae Suai and Mae Fah Luang. The southern part is connected with Phayao, Lampang and Chiang Mai. The western part is connected other part is in the eastern districts of Chiang Rai, such as Doi Luang, Chiang Saen, Chiang Khong, Thoeng and Wiang Kaen.



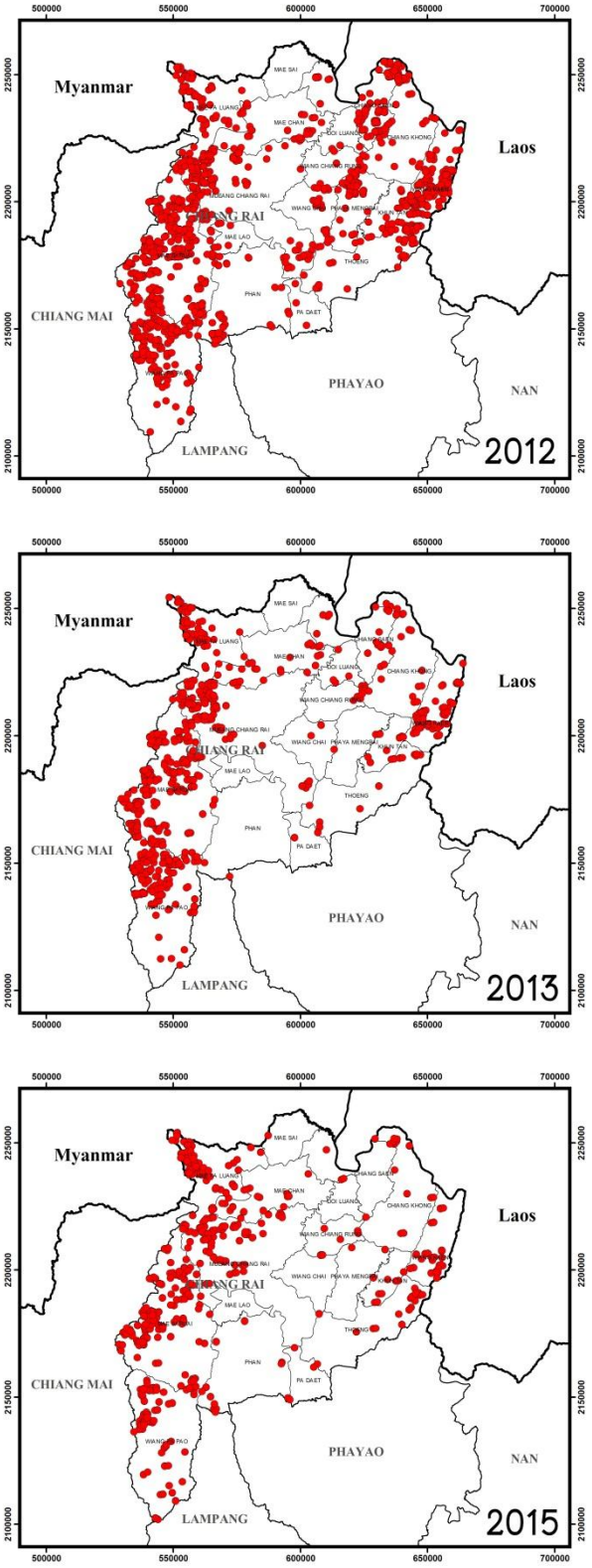


Fig 2: Hotspots Occurrences in March of 2007, 2009, 2010, 2012, 2013 and 2015 in Chiang Rai Province respectively.

Especially in highland areas. Most of the area is forest, which is in line with Dr. Sutine's study of burning. The Hotspot in Chiang Mai. Show that the behavior of burning is repeated in the same area almost every year and the burning may be related to the land use behavior of each area [16]-[17].

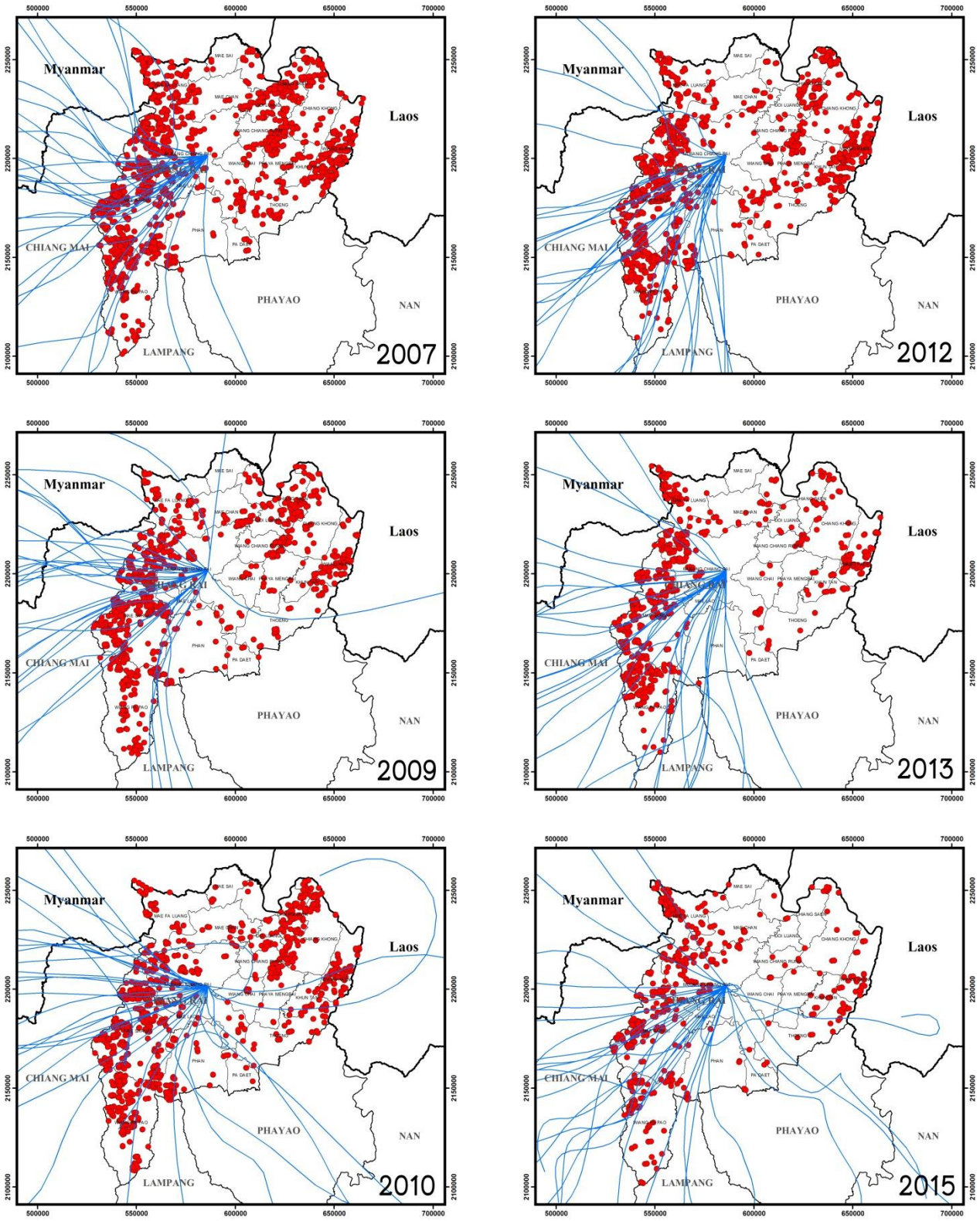


Fig 3: Daily Backward Trajectories Generated for March 2007, 2009, 2010, 2012, 2013 and 2015 respectively

Long-range transport

In this research, daily backward trajectories in March 2007 to 2015 from PM_{10} station in Chiang Rai were brought to analysis. Using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT4) model,

the main backward trajectories patterns moved across the south-western part of the study area, where hotspots were frequently occurred. Consequently, smoke haze problem in the province was influenced by burning from the upwind regions where PM_{10} was steadily accumulated until reaching PM_{10} station in Chiang Rai (Figure 3).

However, from the study of the back ward trajectory of the PM_{10} station in Chiang Rai between March 2007 and 2010, Sirimonkonlertkun found that air mass (wind) is a movement in the south west [18]. Some days start from the Republic of the Union of Myanmar to Chiang Rai. It moves through areas with dense heat points in the Republic of the Union of Myanmar to Thailand through Chiang Mai before reaching Chiang Rai. Reference [19] studied the movement of air mass into Chiang Mai during the crisis of haze. Most of the masses are moving north-south to Chiang Mai. So in this case it is possible that the increase in PM_{10} at Chiang Rai station has been influenced by the burning of neighboring countries and neighboring provinces as well.

The field survey

From the field survey, it was found that the burning in March was often burned on high ground and burned simultaneously throughout the area, as shown in Figure 3. The villagers had to prepare the area before the plantation. Rainfall will be once before Songkran Festival, most of which will prepare the area for planting maize in accordance with the data shown in study of Suti and her team that preparing the area for planting in the highlands, people have no choice but to burn [20].

Fig. 3: Open Burning in Northern Part of Thailand, Chiang Rai Province.

The field survey shown most of hotspots located in the burning area at high elevated forest area for land preparation of the maize plantation consistent of [17]-[18]. Therefore, the solution to the smoke-and-haze problem in the province needs to be conducted with the land utilization in high elevated area.

Fig. 4: Maize Plantation after Open Space Burning Activities in Chiang Rai Province.

5. CONCLUSION

The result of this study showed that the smoke-haze problem in the Chiang Rai area is caused by open burning in the area where the burning characteristics are repeated every year. That means human behavior in that area. At the provincial level, risk areas, or surveillance areas should be initiated from these areas. In addition, the study also shows that due to the large scale of urban sprawl, annual crops plantation as maize to other permanent crops such as rubber, coffee which help to reduce the burning activity after harvesting and maintain the sustainability of the natural resources and environment.

Thus, solving the haze caused by burning in the open space. It should be done in conjunction with solving the burning problem of neighboring areas as well as should be modified and planned at the national level as well.

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