

## 1.2. THE TALK: “Chiang Mai Burning Season: What new data can (and can’t) tell us about the problem”

### 1. Air Pollution and the significance of pm2.5

Air pollution is defined as “The presence in or introduction into the air of a substance which has harmful or poisonous effects”.

This definition covers a wide range of pollutants, but the six major pollutants typically monitored by governments and environmental protection agencies are as follows:

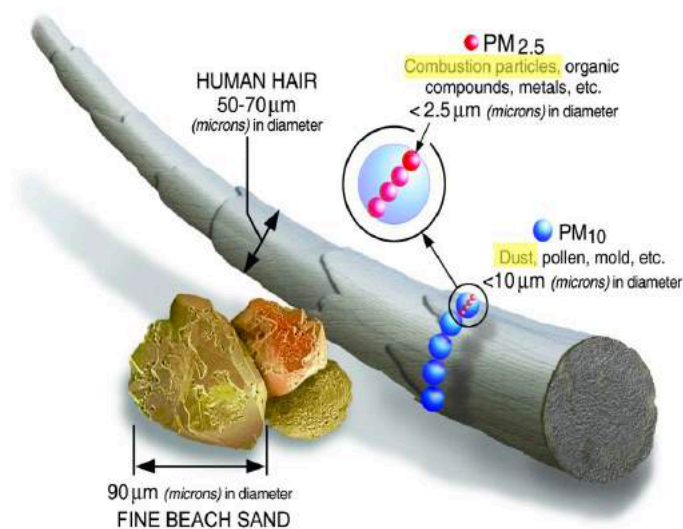
- Carbon Monoxide (vehicle and machinery exhaust)
- Lead (ore and metal processing, incinerators, batteries)
- Ground level ozone (industry, utilities, vehicle exhaust)
- Sulphur Dioxide (Fossil fuel burning by utilities & industry)
- Nitrogen Dioxide (burning fuel for transport and energy)
- Particulate matter (fires, construction, power plants)

The last of these pollutants, particulate matter (PM), is a complex mixture of extremely small particles and liquid droplets that get into the air. Once inhaled, these particles can affect the heart and lungs and cause serious health effects<sup>1</sup>.

The principal sources of particulate matter pollution are fires, construction, and power plants. These sources of PM result in particles of varying sizes, with construction dust generating larger particles and fires generating much finer particles. The size of these particles has important health implications, therefore it is vital to monitor the right size of particle based on the principle pollutant source in your location. For Chiang Mai, the principle source of particulate pollution is burning, therefore we need to monitor the smallest particulates in order to fully assess the health impact.

For public health reporting particulate matter is classified into two size categories: PM10 which are inhalable parcels with a diameter of 10 micrometers or less, and PM2.5 which are fine inhalable particles with diameters of 2.5 micrometers or less.

During the burning season in Northern Thailand, the main pollutant of concern are the smallest PM2.5 particles. These particles are especially dangerous to health because they can penetrate deep into the lungs and enter the bloodstream unfiltered. That can lead to permanent DNA mutations, heart attack and premature death.



<sup>1</sup> <https://www.epa.gov/pm-pollution>

## The main sources of PM2.5 pollution in Northern Thailand are:



### Forest fires:

- Forest clearing, including to harvest mushrooms
- Flushing out game
- Accidental
- Cross border



### Burning agricultural waste:

- Open air burning of cost residue
- Rice field burning
- Leaf litter

One of the largest ever studies carried out on the impacts of air pollution, studied more than 300,000 Europeans over 13 years found that every 5 microgram per m<sup>3</sup> ( $\mu\text{g}/\text{m}^3$ ) increase in pm2.5 was associated with an 18% increase in the incidence of lung cancer.<sup>2</sup> During smoky season in Chiang Mai PM2.5 concentrations are regularly in the range of 50 - 110  $\mu\text{g}/\text{m}^3$  (AQI 137- 179).

## TAKE-AWAY 1: If you want to stay alive, check 2.5

### 2. Building a citizen's network of air quality sensors

**Government**

- + Highest accuracy
- + Extensive validation
- Cost (\$20,000 - \$80,000) + maintenance
- Space and power requirements
- Accessing data

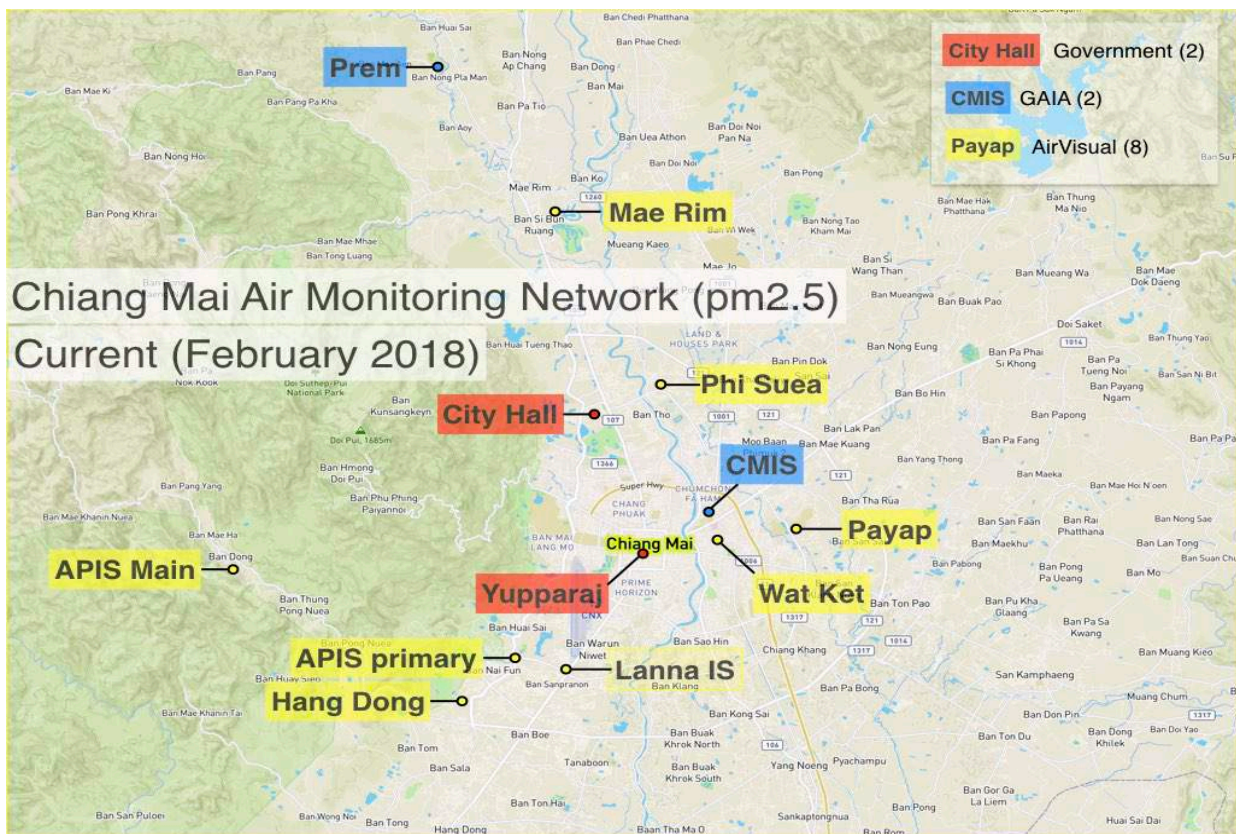
**Low-cost consumer sensors**

- + Cost (\$200-300)
- + Ease and speed of deployment
- + Connectivity and realtime reporting
- Less extensive validation
- Sensor degradation

Currently the Thai Pollution Control Department uses PM10 as the reporting standard for particulate pollution, although it does record PM2.5 data at two monitoring stations in Chiang Mai. Since the main type of particulate pollution in Chiang Mai is PM2.5 caused by burning, it is important to monitor this more closely.

However, one of the challenges of expanding on the current air monitoring network to include more PM2.5 measurements is cost. The type of stations that governments use to measure particulate pollution are large and expensive (\$20k-\$80k). These are high precision scientific instruments which have extensive validation. They require significant space and power.

<sup>2</sup> [http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045\(13\)70279-1/abstract](http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(13)70279-1/abstract)



Fortunately, recent developments in low cost laser particulate sensors have made high quality pollution monitoring more accessible. So we decided to build our own citizen's network of PM<sub>2.5</sub> sensors around Chiang Mai and northern Thailand using this type of sensor.

As of late February 2018 we have 10 sensor installed around Chiang Mai city, with additional sensors in Chiang Dao and Pai.

All of this data is being shared freely on [chiangmaiair.org](http://chiangmaiair.org) and [airvisual.com/thailand/chiang-mai](http://airvisual.com/thailand/chiang-mai)

**TAKE-AWAY 2: This will be the most closely monitored smoky season ever. Make use of the data!**

### 3. What the data can tell us

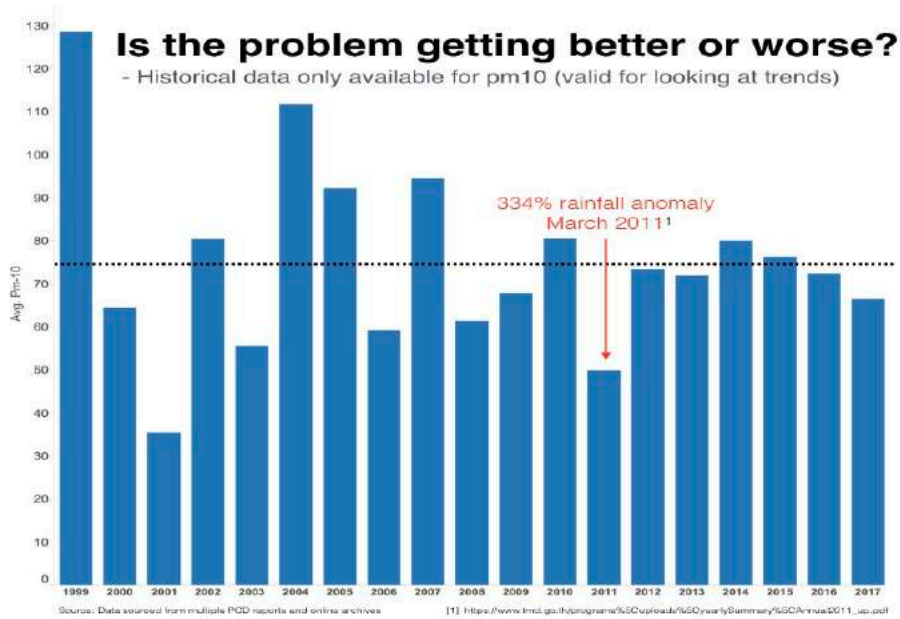
#### a) Is the problem getting better or worse?

To answer this question we need access to a long-term reference of data. Fortunately PM<sub>10</sub> data has been recorded in Chiang Mai for several years and although PM<sub>10</sub> is not ideal given the discussion above, it does allow us to identify the trend over time.

By piecing together data available from the Thai Pollution Control Department we are able to construct a PM<sub>10</sub> timeseries back to 1999. The chart below shows the average PM<sub>10</sub> concentrations for year during the period 1 January to 30 April.

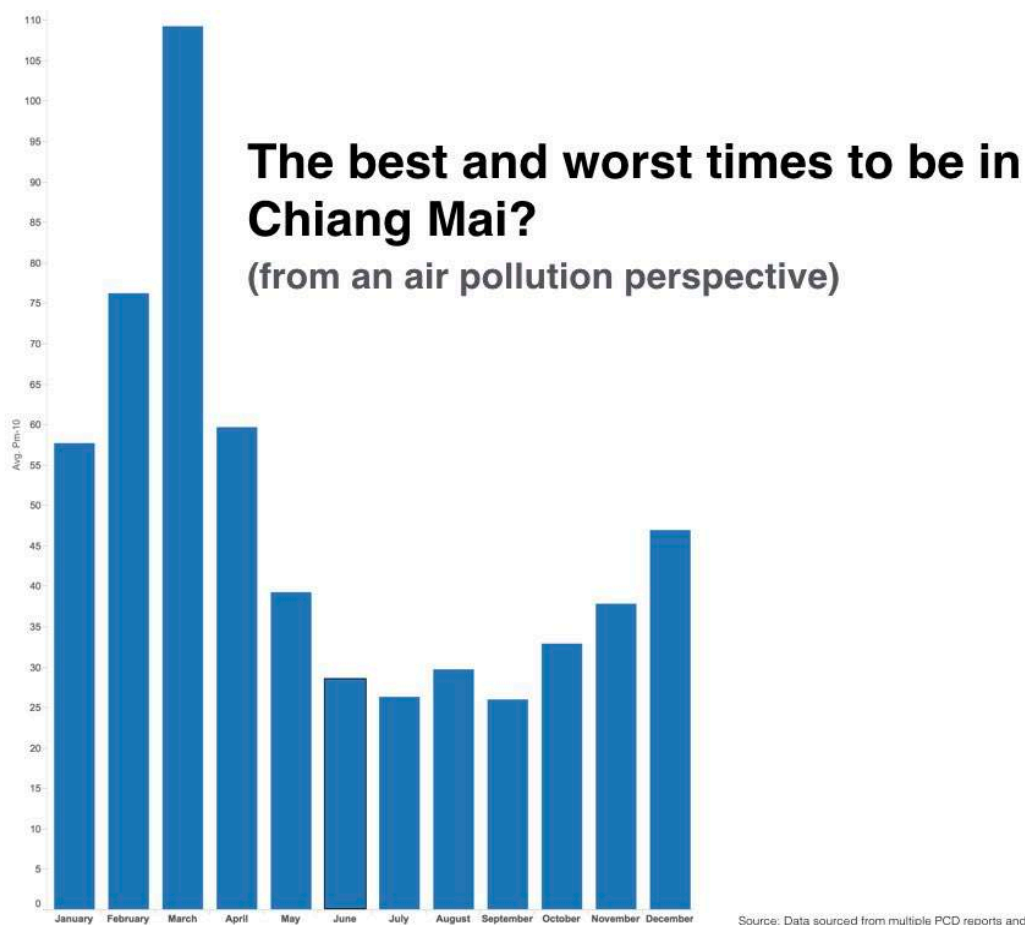
Looking at this data (Next page) we can note a couple of observations:

- In the past we had some very high pollution years, including 1999 and 2005. Over the last 10 years we have not experienced any extreme years like these.
- Weather, and in particular rain has a very significant impact on pollution levels. This can be seen from the low average for 2011, which was a result of extremely high rainfall during March of that year.



- The PM10 over the last few years have been about average, so no significant difference compared to the long-term.
- Over each of last 4 years there has been a slight decrease in PM10 during the smoky season. It is not clear what the cause of this decrease is, although during 2017 Chiang Mai experienced significant rain in January, and also in mid April.

#### b) What time of year is the pollution worst?



Again we need a source of long-term data to understand the average pollution levels during each month of the year. For this we need to rely again on the historical PM10 record, which tells us the following:

- On average, the worst month for PM10 pollution by a significant margin is March.
- February, April, and January have the next highest levels of PM10.
- Nor surprisingly, the cleanest air occurs during the rainy season with the lowest PM10 values measured between June - September.

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**c) My neighbor is burning stuff, how bad is the air?**

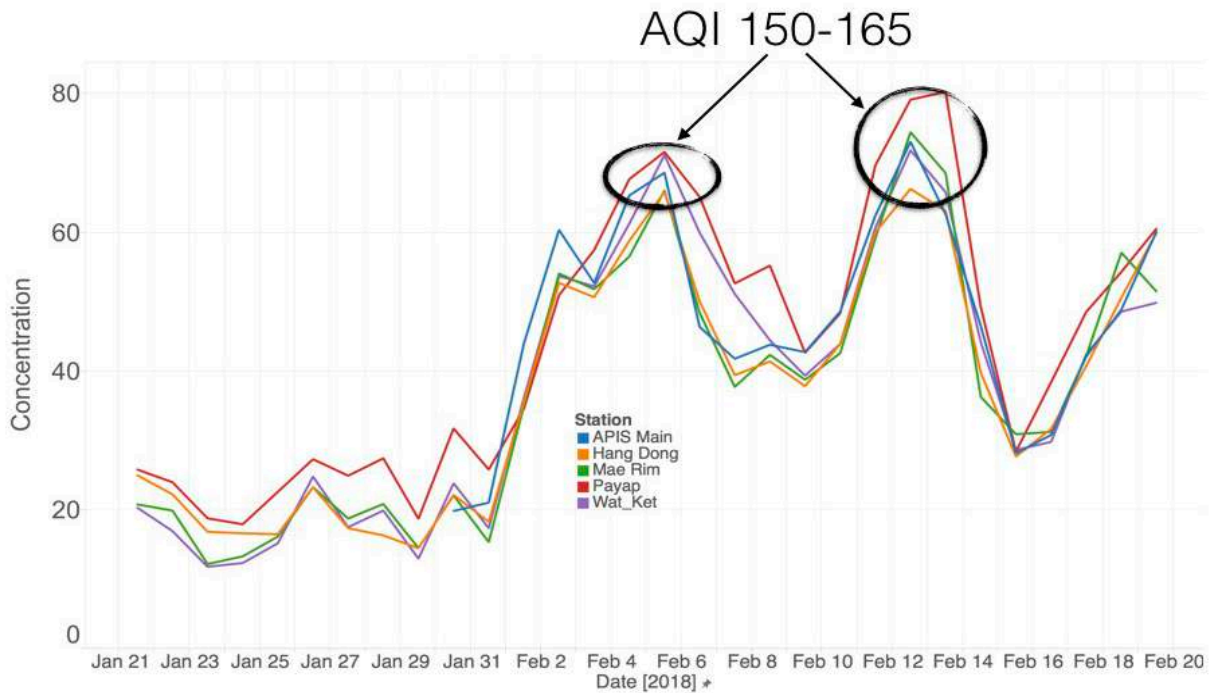


Of course this is very dependent on the individual situation, but as a result of having sensors deployed across the city, we can now pick up localized burning events and understand the impact these have on short-term air pollution.

As an example, one of our sensors in the Phi Seua area of the city picked up burning by a neighbor. The image below shows the very smoky view during that time and the reading of the sensor was over 1000 AQI. As our network continues to record data we will start to build a more complete picture of how this type of localized burning impacts air quality and how far it spreads. Our initial measurements during the early 2018 season suggest this type of burning is occurring around the edges of the city where farm land meets the city.

**d) Where in Chiang Mai can I avoid the worst of the pollution?**

By deploying a large, spatially distributed sensor network, we are beginning to build a much more granular picture of the air pollution and it's reach. The bad news is that during the peak smoky season in Chiang Mai, the smoke layer is easily large enough to encompass the entire city and some way beyond. That means there really is no place within the city that has significantly better air than another. We know this because during high pollution periods we see all of our sensors recording consistently high levels of PM2.5. The chart below shows PM2.5 concentrations recorded by our network of sensors during such an event in early February 2018. These five stations cover a broad area from downtown Chiang Mai, to Mae Rim in the north and Hang Dong in the southwest.



Source: Data sourced from multiple PCD reports and online archives

#### e) What the data can't tell us

- The reason for the pollution (See "Future work" below).
- The long-term health impacts for individuals.
- How to fix the problem (but if can inform our solutions).

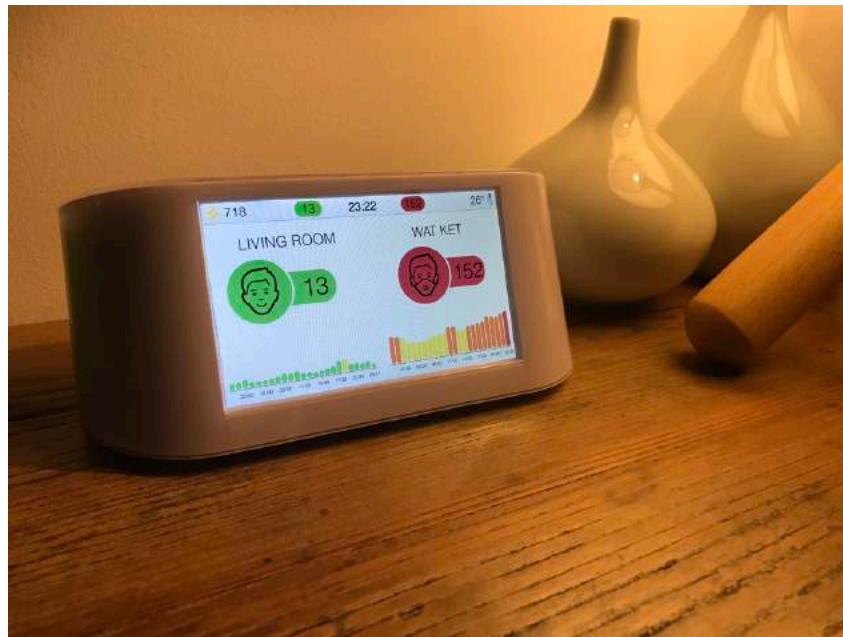
**TAKE-AWAY 3: During peak pollution days our smoke layer easily covers all of Chiang Mai. Assume it is bad everywhere.**

## 4. Air purification

Given the growing body of evidence highlighting the dangerous impacts of particulate pollution, and the knowledge that Chiang Mai suffers from periods of very high PM2.5, it is important to protect your health during the smoky season.

One of the most effective actions you can take is to seal your house and run air purification inside to lower your exposure to particulate pollution. If done properly this can be very effective and reduce your exposure significantly. The image below shows the indoor (left) and outdoor (right) AQI for a house in Chiang Mai, which was sealed and running several purifiers. Even when the outdoor PM2.5 was high, the indoor air quality remained excellent. This represents a 95% reduction in PM2.5 concentration using this approach.

Sealing your house is important to slow the entry of PM2.5 particles into your living space. Once this is completed, purification using a High Efficiency Particulate Air (HEPA) filter can be added to eliminate the particulates. In order to fully clean the air, purifiers must circulate the all the air in the room through the filter several times. However there is a limited volume of air that each filter can process in an given time - so for large spaces, or when the outdoor air is very polluted, it will usually be necessary to have several filters running. For a useful review of air purifiers and understanding their effectiveness see the following article: <https://thewirecutter.com/reviews/best-air-purifier/>



Although not specifically covered in this talk, pollution masks can be an effective way of reducing your exposure to PM2.5 if you have to be outside during periods of high pollution. Look for mask that are rated N95 or higher. Inexpensive N95 masks by 3M are widely available in Thailand. N99 masks by Vogmask are also highly rated if you need additional protection. In order to be effective masks must be well sealed against the face.

**TAKE-AWAY 4: Air purifiers really work (as long as your house is well sealed and you have enough purifiers for your size of room/house).**

## 5. Future work

We hope our citizen's network of PM2.5 sensors will help provide the data needed to support future research and inform solutions to our smoke problem in Northern Thailand. Our data will be freely available to anyone who wants to use and it opens up the possibility of some exciting future work, including:

- Pollution source identification using combination of ground stations and satellite tracking. This would allow us to trace pollution back to the source and understand which sources are the major contributors to our air pollution problem. This will help policy makers focus their limited resources on the most significant contributors to PM2.5 pollution.
- Building hospital admission forecasting models using live data and machine learning. This could provide public health administrators with real-time actionable information to help them plan more effectively for the increased level of hospital admissions observed during smoky season.

**Note: The original slides presented at the talk are available at:**

<https://drive.google.com/open?id=1NCqxpPlmj1hITs0EJEQyCCIVcULeSZOj>

