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Analysis of transported pollution and haze-related diseases via HYSPLIT Trajectory Modelling in the urbanized area of Johor, Malaysia

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Abstract. Exposure to the haze pollutants may cause a diverse range of health impacts including symptoms that lead to treatment-seeking behavior, outpatient and emergency department visits, and hospitalization for moderate and severe cases and mortality for the worst-case scenarios. This study is carried out as an effort to understand how the haze occurrence that has been plaguing South East Asia affect the health of the citizen in Malaysia, particularly in Johor due to its close proximity to Sumatra which has been identified as one of the hotspots for frequent forest fires. The study is done in Larkin and Pasir Gudang where health cases caused by poor air quality such as conjunctivitis, URTI and asthma have been identified while HYSPLIT model indicates the trajectory of the wind at different heights to help us understand how wind movement during the selected time of the year causes haze formation. The findings of this study showed that low wind heights below 2000m AGL in September cause particular matter accumulation over Malaysia as the wind over Malaysia. In turn, this causes high API reading which leads to higher conjunctivitis, URTI and asthma cases. The investigation of the exposure and health risks of the air pollutants through a risk-based approach will definitely be beneficial in providing new information about the correlation between health risks and air pollution in Johor, which may also have implications on the environmental and social policies.

1. Introduction

Haze is an atmospheric phenomenon in which dust, smoke and other dry particles disturb the sky's clarity. Wu et al. [1] define atmospheric haze when the visibility is equal or less than 10km with relative humidity (RH) less than 90%. T. Wang et al. [2] also mention that haze weather is considered to occur when the PM_{2.5} reading is higher than 80 µg/m³. In another definition of haze, it is described as presence of fine particulate matter dispersed through a part of the air at elevated concentration that decreases horizontal visibility, producing opalescent appearance weather [3]. Haze has been identified as an



environment occurrence that originates from different place but the haze occurs somewhere else. The aerosol particulate matter is usually carried by the wind onto a different location where it will eventually reach stable atmosphere and gather to form haze at that different location. Haze forms when the aerosol particulate matter remains stagnant due to lack of wind movement to carry away the aerosol particulate matter in the air where it will then accumulate in the troposphere to form haze. However, haze can be dispersed by windy condition or when it water droplets from rain combine with the aerosol particulate matter to form liquid drops which are also known as condensation. The haze problem first started around 1997 occurs usually during the dry season in which land clearing is done through slash and burn to make way for palm oil plantation. This is due to the greater global demand for palm oil which has become the basis for many daily consumer products. Haze contains dust and smoke particulate matter that is very small particulate matter. It has been known to cause serious health damage to human if exposed for a long time. Some of the health implication, when exposed for too long, are irritation in the nose, ear and throat, respiratory system disruption especially affect bronchitis in the lung and skin condition such as eczema.

In Malaysia, the Department of Environment (DOE) controls the air quality status through a network of 52 automatic stations. In terms of the Air Pollutant Index (API), Haze is evaluated with a range of values to determine the distinct haze severity levels. The API ranges from Good 0 – 50, Moderate 51 – 100, Unhealthy 101 – 200, Very Unhealthy 201 – 300 and Hazardous above 300. The API calculation formula used in Malaysia and other ASEAN countries follows the U.S. Environmental Protection Agency (USEPA) based on a research of pollutant exposure to human health variables. Air Pollutant Index (API) is a measurement of the effects of 5 major concentrations of air pollutants (fine particulate matter measuring less than 10 μm (PM_{10}), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and ground-level Ozone (O_3)) on a normal human's health over a specific time of exposition. Pollutant with the highest concentration will be used to be calculated for the index.

A thorough evaluation of health risks has now become relevant as such practice serves as the grounds for any re-formulation or review of the present air quality standards [4]. A thorough research on the relationship between haze pollutions and the related negative health effects is therefore extremely needed to reduce (if not entirely prevented) such undesired effects on human well-being should the haze episode recur in the future.

1.1 Definition of Haze Event

Malaysia Meteorological Service has defined haze event as the presence of fine particles (0.1–1.0 μm in diameter) dispersed at a high concentration through a portion of the atmosphere that diminishes the horizontal visibility, giving the atmosphere a characteristic opalescent appearance [1]. Meanwhile, haze is defined by China Meteorological Administration as a pollution phenomenon which cuts atmospheric visibility to below 10 km due to complex materials that are suspended in the atmosphere, such as the solid or liquid particulates, dust, smoke, and vapour [5]. Haze may occur if the relative humidity is less than 80% when air is polluted with dry particles like $\text{PM}_{2.5}$ and PM_{10} and gases like ozone, nitric oxide, nitrogen dioxide and sulfur dioxide [6]. These events have occurred when particle aerosols accumulate in the air and scatter and absorb solar radiation, leading to atmospheric opacity and impaired visibility. Previous study stated that basic components of haze are particulate matter (e.g., metals, nitrates, sulfates, organic carbon, microbial components, pollen), gases (e.g., ozone, sulfur dioxide, nitric oxide, nitrogen dioxide, carbon monoxide, carbon dioxide), and volatile organic compounds (e.g., Benzene), [7].

In general, the haze event happens during the dry season (southwest monsoon), which is drier than normal in Sumatra and the southern part of Borneo, often leading to large and uncontrollable forest fires. The southwestern (summer) monsoon, marked by low southwesterly winds, starts in May and generally lasts between 3-4 months and August. With prevailing winds blowing northwestward during this period, extended and large scale forest fires in Sumatra and Kalimantan are almost certain to cause severe haze episodes in Malaysia and the greater Southeast Asian region. Figure 1 shows the wind pattern over the South China Sea, typical during the Southwest monsoon.



Figure 1 Climate in Malaysia during haze episode (June, 2013)

1.2 Composition of haze

Wang et al. (2003) pointed out that fine particulate matter are the major components of atmospheric aerosol and all particulate matter indicate strong spatial variation [8]. Some of the particulate matter that contributes to haze are elemental carbon and also polycyclic aromatic hydrocarbons (PAHs) [9]. Besides that, particulate matter that is rich in potassium (K) has been identified as one of the main components in a haze. K rich particulate matter being of the major components of inorganic aerosol has been identified as the major contributor to brown haze which comes from biomass burning and combustion.

It is to be noted that the concentration of haze particulate matter varies based on the distance. Area nearer to the source of the aerosol particulate matter will have higher concentrations of particulate matter. In a study by Betha R et. al [10], she found that samples collected near to the vicinity of the peat fires show a spike in the reading. Betha R et. al [10] also found that 12 trace metal elements (Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Ti, V and Zn) in PM_{2.5} that was studied by her. Al, Fe and Ti are the major fractions inside the total metal concentrations in the PM_{2.5} emission caused by peat fires.

Liu et al. [11] conclude from the findings of his experiment that concentration of primary air pollutants increases except NO which could be due to the scavenging process of O₃. O₃ that is formed from the photochemical reaction between VOCs and NO_x with the aid of heat and sunlight [12].

1.3 Activities that contribute to the formation of haze

Biomass burning is a common agriculture practice among farmers especially in developing countries where these farmers look for the cheapest alternative in clearing lands. Biomass burning is a major source of aerosol particulate matter especially in Southeast Asia [13-19]. However, biomass burning is a major source of primary particulate matter which is organic matter and K rich particulate matter together with soot and poisonous gases such as VOCs and , SO₂ [9]. These fine soot particulate matter especially aerosol particulate matter are emitted into the air which will then carry over the Pacific Ocean. These soot particulate matter then combine with sulphates that have been identified to absorb up to 30% more light than soot itself [20].

Besides meteorological factors, strong emission intensity leads to haze occurrence [11]. Variation in primary pollutants showed no consistency due to various different sources and lifetime especially in an urban region where vehicle emission is a lot higher as compared to in rural regions. However, variation in nitrogen dioxide (NO₂) is similar to the trends of PM_{2.5} suggesting that accumulation of urban emissions played a significant role in the formation of haze pollution.

Vegetation and peat fires that occur across Southeast Asia could be linked to El-Nino droughts and anthropogenic land clearing [21]. The fire that lights up the forest results in deforestation and forest degradation [22] which releases huge amount of carbon dioxide (CO₂) and other atmospheric pollutants

which degrade regional air quality and human health [23-25]. In the study by Reddington et al. [18], he states that the haze that Singapore regularly experience come from local emission from the PM industry and transportation in addition to long-range transport of particulate matter from fires. Air that picks up particulate matter from region of fires will increase concentration of PM_{2.5} [10,18] and result in poor visibility [17]. Some of the traces of particulate matter that come from biomass burning are from concentration of levoglucosan [10] which further confirm that biomass burning contribute to the formation of haze.

Smoke haze formed from the action of human burning forest and peat fires in Southeast Asia is a major problem faced by Southeast Asia countries as it has a great impact on regional air quality. It was found out that aerosol emission from the fire in southern Sumatra contribute the most to PM_{2.5} concentration in Singapore (42-62%) while the fire in central Sumatra and Kalimantan contribute 21-35% and 14-15% respectively. The anthropogenic emission also affects other major cities in Southeast Asia. The regular occurrence of forest fires caused by Indonesia induces haze as the forest are being logged and slash-and-burn technique to develop agricultural lands [18-19]. Peat fires in Southeast Asia occur from human cause where forest are intentionally lit up to make way for agriculture and also to manage their crop [26]. Extensive drainage is one of the other factors that cause peat lands to light up.

Some of the particulate matter that is present in haze could be caused by natural phenomenon including oceans, forests and ground surface. However, that is a natural occurrence that contributes only a small fraction of particulate matter. A spike in particulate matter concentration is usually caused by human activities such as open burning, slash-and-burn to clear land and intensive vehicular usage and coal-powered generator plant. All these activities release carbon monoxide, Sulphur dioxide, nitrogen dioxide, ozone, dust and trace metals which all are elements of haze. Besides that, the occurrence of yearly forest fires in Sumatra, Indonesia due to human intention to clear land on such a huge scale for both local and foreign palm oil plantations coupled with the monsoon winds blanket parts of Southeast Asia every year. Currently, Malaysia and Singaporean palm oil companies hold more than two-thirds of Indonesia palm oil business plantation [27] Malaysian companies have an investment of up to \$702.4 million in terms of palm oil plantation over in Indonesia [28]. Some of the prominent companies in Indonesia like Bakrie Sumatra Plantations, Duta Palma, Astra Agro and Malaysia's famous palm oil company Sime Darby, Genting plantation and IOI plantations are some of the accused companies that carry out illegal slash-and-burn to clear lands in Indonesia as this is the cheapest method to clear land. Based on expert, this method is up to 40 times cheaper than using a machine to clear land [29].

Afroz R. et al. (2003) reported that some of the major sources of air pollution in Malaysia are vehicle usage (70-75%), stationary source (20-25%) and open burning (3-5%) [30]. The use of inefficient diesel-powered vehicles in Malaysia and aerosol smoke leads to the formation of haze in Klang Valley [31-32]. Mills especially cement and asphalt plants discharge a huge amount of particulate matter into the air which further worsens the air quality. In the early 1990s, Klang Valley which undergoes exponential development needed to clear land just as fast as the development goes which causes a lot of construction activities and land clearing to occur [33](Sham S et al., 1991). This statement is further fortified by the conclusion that rampant industrial activities and exponential use of personal vehicle lead to huge jump in emission of gaseous pollutant especially NO_x and SO₂.

2. Methodology

2.1 Selection Study Area

With prevailing winds blowing north-eastward during this period, prolonged and large scale forest fires in Sumatra and Kalimantan are almost certain to cause brought plumes from fires in Borneo to Southern part of Malaysia especially Johor state. Therefore, this study was conducted in Johor state. Figure 2 shows two of the Continuous Air Quality Monitoring (CAQM) and the nearby health clinics located in the urban areas of Johor.

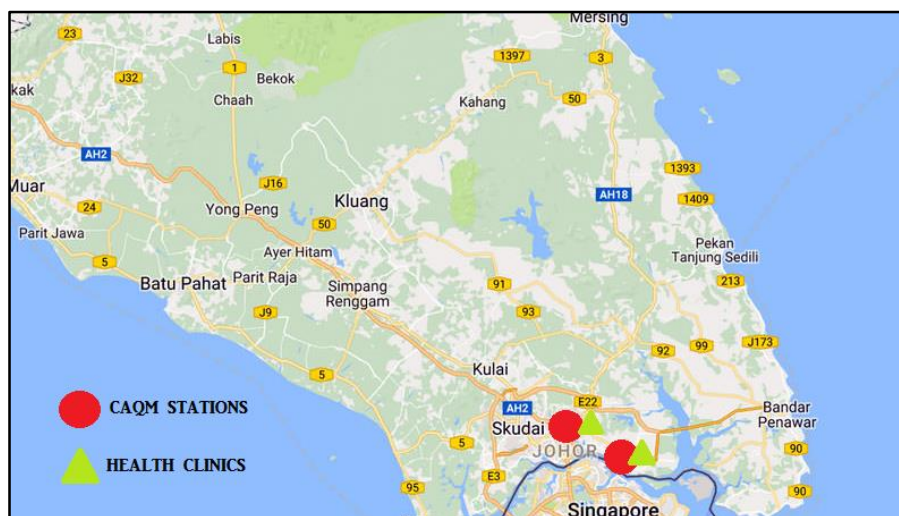


Figure 2 Spatial distribution of CAQM stations and studied health clinics in Johor

2.2 Data Needs and Sources

After the areas (locations) of the study has been decided, data collection will be conducted to acquire the relevant data for the study which includes the air quality data from Malaysian Government of Natural Resources and Environment, database on visitation rates, health treatment (outpatients), and illness types which can be obtained from the selected public hospitals and clinics.

2.2.1 Air quality data

Data on air quality in eight CAQM stations in Johor will be obtained from the Department of Environment (DOE), which is operated by Alam Sekitar Malaysia Sdn. Bhd. (ASMA). The data is composed of mean daily ambient concentrations of particulate matter less than 10 μm (PM₁₀) in mg/m^3 , SO_2 in ppm, NO_2 in ppm, ozone (O_3) in ppm, and carbon monoxide (CO) in ppm. The data is reliable and fit the purpose of doing research works since the monitoring instruments and operation protocols for the CAQM stations in Malaysia are approved by the U.S. Environmental Protection Agency (USEPA). Quality control protocols governing fieldwork, analysis and data handling, analysis and interpretation are implemented by ASMA on a regular basis. The details of the methods and instrument used are shown in Table 1.

2.2.2 Health clinics outpatient data

The monthly and annual data of morbidity for outpatient during the haze and non-haze periods will be obtained for health clinics from the Ministry of Health (MOH) Malaysia via the Health Informatics Center (HIC). The eight health clinics in both rural and urban areas that are adjacent to CAQM stations will be chosen. Data including gender, age group and type of disease diagnosis adhered to the World Health Organization's International Classification of Disease (ICD 10) for haze-related illnesses will be obtained from January 2014 until the most recent year.

2.3 Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Model

HYSPLIT model is used as a transport & dispersion modeling under the Air Resources Laboratory (ARL) under National Oceanic and Atmospheric Administration (NOAA). HYSPLIT is famous as being used to determine if the high level of pollutants at a location is caused by transport of air from another different location. It is a tool that explains how, when and where these air particulate matters are

atmospherically transported, dispersed & deposited. By default, the model uses a 3-dimensional particle distribution (horizontal and vertical).

There are two types of trajectory available in the model. One of it is forward trajectory where it provides an estimate of the path that air followed moving forward in time beginning at the start location. Forward trajectories help by analysing where did the air go. On the other hand, backward trajectory provides an estimate of the path that air followed prior to arriving at the start location.

Table 1: List of the instrument used by the DOE in the air quality monitoring network in Malaysia

Variable	Instrument (Teledyne, USA)	Measurement Principal	Precision	Detection limit (DL)
O3	Analyzer 400A	Chemi-luminescence	0.5% (<10s)	0.04 ppm
NO, NO2,NOx	API 200A	Chemi-luminescence	0.5%	0.4 ppb
SO2	API M100A	Florescence	0.5%	0.4 ppb
CO	API M300	Non-dispersive infrared absorption (NDIR)	0.5% (<10s)	0.04 ppm
CH4	API M4020	Flame ionization detector (FID)	1%	
NmHC	API M4020	Flame ionization detector (FID)	1%	
TSP	HVAS			
PM10	BAM 1020	Met-One Beta Attenuation		<1.0 $\mu\text{g m}^{-3}$ (24 h)

Legend:

“-“ = no data

API = advanced pollution instrumentation

HVAS = High volume air sampler

BAM = Beta Attenuation Monitor

2.3.1 Model Setting

The model is set to run for 240 hours (10 days) with a start time of 00 hours on the 15th of every quarter year using meteorological data from archived data sets which is GDAS (0.5 degree, global, 09/2007 – present) as this meteorological data have global data and is of higher resolution as compared to the others. Forward trajectory is used to see where the air goes from Sumatra and West Kalimantan. 3 above ground level (AGL) heights are set which are 100m, 500m and 1000m. The plot resolution is set to 300 dpi which is the highest resolution available while the zoom factor is set to 150. The model vertical velocity is used for the vertical motion.

In the trajectory result, the red line represents 100m air height, blue represents the 500m air height while the green line represents 1000m air height. As selected, all the trajectory start on the 15th of March, June, September and December respectively and run for 10 days. The 3 different AGL heights used allow us to see how different stability of atmosphere at different height aided the transport and dispersion of the air.

3. Results and Discussion

Table 2 represents the number of cases experienced by the clinic in Larkin and Pasir Gudang in dealing with patients (general) and patients who suffer from conjunctivitis, URTI and asthma respectively. The number of cases is based on five working days per week. Pasir Gudang serves a higher number of

patients as compared to Larkin including haze related illness. However, Pasir Gudang has the highest number of patients in September while Larkin has the highest number of patients in March. Larkin and Pasir Gudang experience a significantly higher API reading in September in which it is nearing to 100 which puts it into the unhealthy zone. This indicates that there are signs of worsening air condition in September which could indicate the occurrence of haze.

Table 2: Number of health cases in Larkin and Pasir Gudang

	Larkin					Pasir Gudang				
	Avg API	Total Patient	Conj	URTI**	Asthma	Total Patient	Conj	URTI**	Asthma	
March	60	4176	70	533	47	50	7570	105	1120	126
June	50	4023	20	628	35	55	7609	129	1171	143
September	96	3975	57	668	59	100	8074	126	1229	145
December	43	3792	52	522	44	50	7650	164	1245	139

Data only on working days*

**= Upper Respiratory Tract Infection

Conj = Conjunctivitis

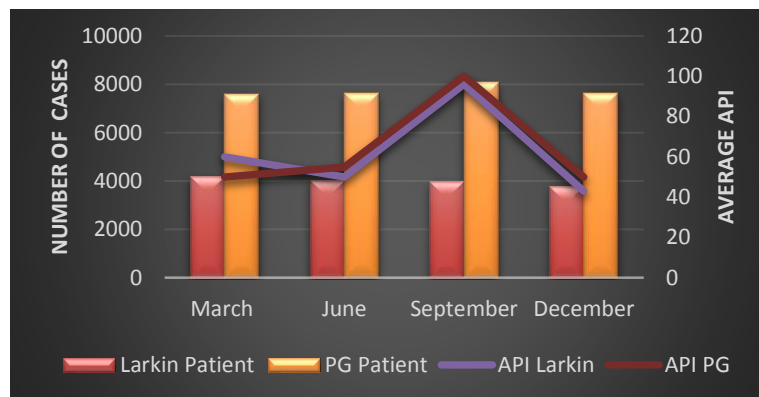


Figure 3: Total Number of health cases during the different month of the year

Figure 3 shows us the total number of health cases experienced by both clinics in Larkin and Pasir Gudang during different months of the year with an indicator of air quality (API) during that particular month. The figure shows that Larkin actually experiences a decrease in the number of patients while Pasir Gudang (PG) actually experience an increasing number of the patient. However, Pasir Gudang experience a significant increase in number of patients of over 400 in September which could be closely related to the poorer air quality but the same could not be said for Larkin.

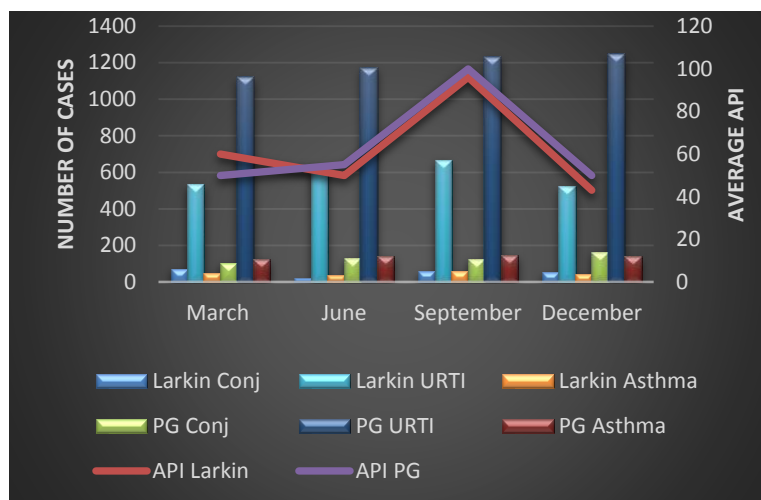


Figure 4: Total Number of poor air quality-related diseases case during the different month of the year

As mentioned before, haze related illness such as conjunctivitis, upper respiratory tract infection (URTI) and asthma was caused by poor air quality. From the data obtained from the clinic in Larkin and Pasir Gudang, the number of morbidity cases is plotted against the API for different months. The data are represented in Figure 4. Figure 4 shows the total number of cases experience by the respective clinic in dealing with health cases that are closely related to poor air quality namely conjunctivitis, upper respiratory tract infection (URTI) and asthma with an indicator of the air quality during that respective month. Larkin experienced an increase in the number of patients suffering from URTI, Conjunctivitis and Asthma in September. In September, Larkin clinic peak the number of cases of asthma where the number of asthma cases increases by about 50% to a total number of cases of 59 as compared to an average of about 40+ cases during the other months. All three sickness experience a decrease in the number of cases in December which is related to the improvement in the air quality.

It is almost the same case in Pasir Gudang where all three cases experience an increase in the number of cases in September. However, in Pasir Gudang, conjunctivitis and URTI actually experience a continuous incremental number of cases throughout the year 2015 but asthma cases only experience an increase in September while the number is down on the other months. It can be concluded that all three sicknesses are more prominent in the event of poor air quality such as what happened in September 2015 where the API reading was nearing the unhealthy zone especially asthma cases where both Larkin and Pasir Gudang experience a higher number of asthma cases.

3.1 Trajectory by Month

Figure 5 shows the forward trajectory of air from Sumatra and West Kalimantan starting on the 15th of March 2015 at 00 hours. The trajectory is run for 240 hours (10 days). In Figure 5(a), the trajectory of different heights of air is shown at the bottom of the figure. The starting heights of air are 100m, 500m and 1000m AGL. Red line represents 100m, blue line is for 500m and green is for 1000m AGL. Air move towards the Pacific Ocean bypassing Malaysia except for 500m and 1000m AGL air from Sumatra. This explains why monsoon season in East Coast Peninsular Malaysia usually end in March as the wind from the ocean does not pass through Malaysia. The 500m and 1000m AGL wind from Sumatra travel up north towards Vietnam.

Figure 5(b) shows the forward trajectory of air from Sumatra and West Kalimantan starting on the 15th June 2015 which run for 240 hours (10 days). The trajectory of different heights of air are shown at the bottom of the figure where the red line represents 100m, blue line is for 500m and green is for 1000m AGL. The figure shows that air move towards the Pacific Ocean passing Malaysia where winds from Sumatra pass Peninsular Malaysia while winds from West Kalimantan passes East Malaysia. The wind

travels directly towards the Pacific Ocean where it will whirlpool. The AGL shows that the wind travels higher into the atmosphere to a height above 3000m AGL.

HYSPLIT model is set for 15th September 2015 to run for 240 hours for forward trajectory. The result of the trajectory is represented in Figure 5(c) where the red line represents 100m, blue line is for 500m and green is for 1000m AGL. From the trajectory, it shows that air disperses randomly in the region but towards the Pacific Ocean. The air disperses randomly throughout the Peninsular Malaysia which could explain why when there is a forest fire in Sumatra during the dry season, haze usually occurs throughout the Peninsular. It can be seen from the AGL that the wind from 1000m from Sumatra actually settle down towards the lower region which could cause saturation and deposition of particulate matter over Peninsular. From the AGL, it can also be seen that the wind settles at a maximum height of just over 2000 AGL which is significantly lower than the wind heights during the other months. Most of the winds accumulate below 1000m AGL. Accumulation of this particulate matter could lead to haze.

Using HYSPLIT model to obtain the forward trajectory for 15th December 2015 has provided us the data as in Figure 5(d) where the red line represents 100m, blue line is for 500m and green is for 1000m AGL. Figure 5(d) clearly shows air at different AGL, while Figure 6 is a zoomed-in version which allows us to clearly see where did the air go. From the trajectory in December, winds from Sumatra travel towards Indian Ocean while the winds from West Kalimantan accumulates in the local region except for wind 1000m AGL. This shows that the air actually travel away from any human civilization. Besides that, most of the wind travel to a height of above 5000m AGL which is very far from the surface. This is why haze does not occur in December as the wind remain high above the ground.

Overall, it can be concluded that wind during June and September pass Malaysia while the wind in March and December does not pass Malaysia. However, wind in June and September differ by the stability of the winds in which wind in June actually travel to higher heights while the winds in September remain at low heights below 2000m AGL. On the other months, the wind travel above 7500m AGL which is significantly higher. The significantly lower heights of air in September explain the accumulation of particulate matter which leads to haze in Peninsular Malaysia.

As mentioned previously, lower air heights and higher downwind stability in September lead to the accumulation of particulate matter especially haze particulate matter in the lower region of Peninsular Malaysia. Slash and burn which is carried out in Sumatra releases a large amount of particulate matter that eventually gets carried by the wind and settle at Peninsular Malaysia as the wind travels from Sumatra passing Malaysia. This causes accumulation which leads to higher API reading and eventually haze episode. Accumulation of haze particulate matter causes higher than normal amount of haze particulate matter in the air which causes unhealthy condition for human. Constant exposure and breathing in this microparticulate matter lead to a health problem such as conjunctivitis, URTI and asthma where these particulate matter causes irritant to the body and affect one's health. Hence, from all the result, it suggests that wind stability hugely influence the heights of the wind dispersion and is one of the causes of haze.

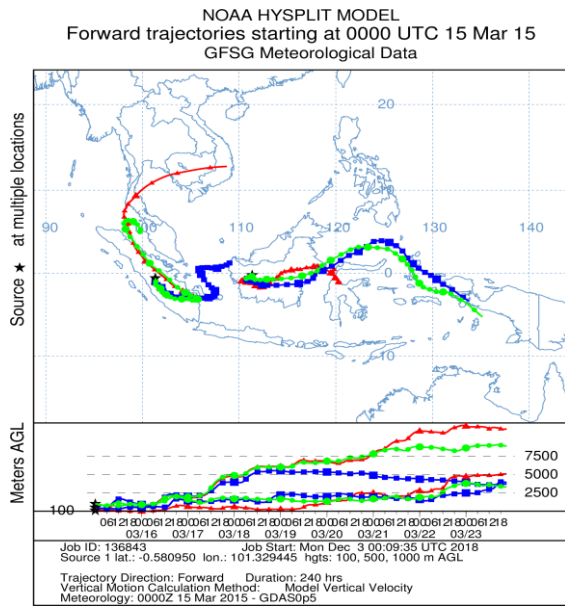


Figure 5 (a): March Forward Trajectory

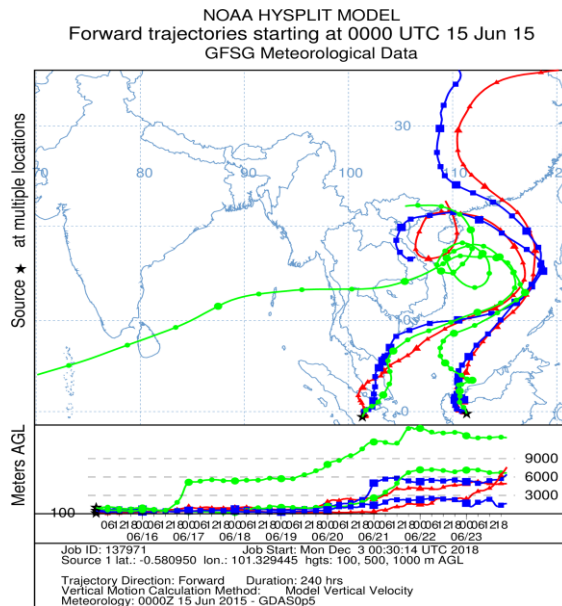


Figure 5 (b): June Forward Trajectory

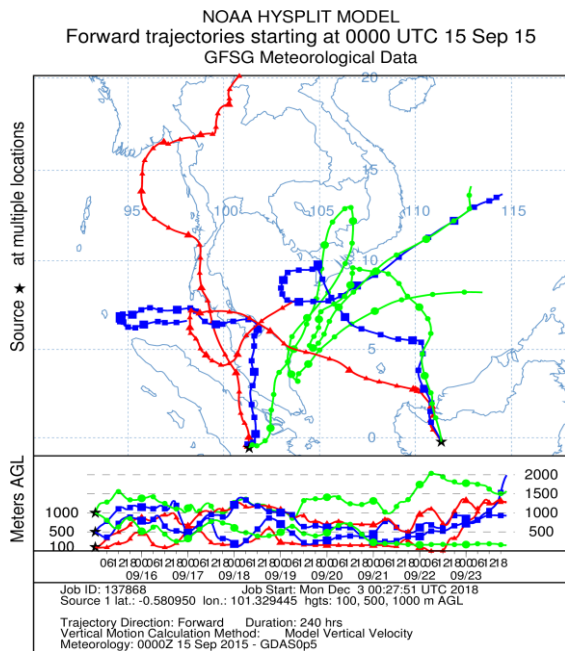


Figure 5 (c): September Forward Trajectory

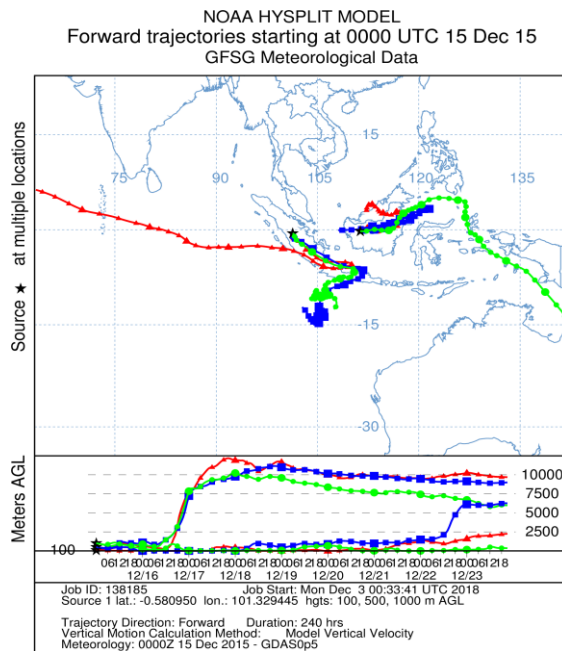


Figure 5 (d): December Forward Trajectory

Figure 5: forward trajectory of air from Sumatra and West Kalimantan

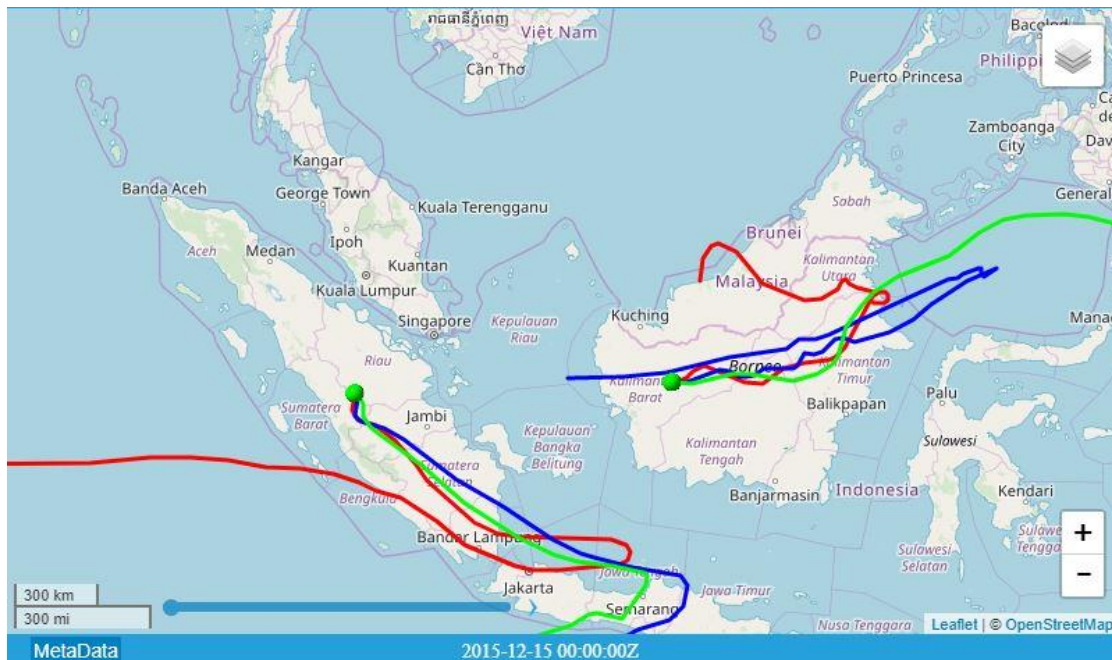


Figure 6: Zoomed in Google Maps view of March Forward Trajectory

4. Conclusion

From this study, the trajectory of the air at different heights above ground level (AGL) provided more insights to understand the characteristics of wind direction in Malaysia at different months of the year. In March and June, wind moves towards the Pacific Ocean and the air travel to a higher height of above 2500m AGL while in September, the wind remains low mostly below 1500m AGL. In December, the wind blows toward Indian Ocean towards a height of 10000m AGL. This explained why Malaysia frequently experience haze between September and October which is due to low wind heights and accumulation of the particulate matter. The findings of this study suggest that downward wind movement in September carries the haze particles from Sumatra towards Malaysia where most of it settles down to a height of below 1000m AGL and some even below 500m AGL. This accumulation causes haze which causes an increase in the number of particulate matter in the air resulting in high API reading. In turn, more patients suffer from conjunctivitis, upper respiratory tract infection (URTI) and asthma during the haze episodes in Larkin and Pasir Gudang. In order to combat this problem, one of the ways is through education of controlled burning to the farmers. Besides that, there is a need for farmers to carry out slash and burn if they have to during the selected period of the year such as in December where the wind will carry the particulate matter released towards the Indian Ocean away from any human civilization. The cooperation between Malaysia, Indonesia and Singapore are also needed to combat the forest fires by using wildfire suppression methods while educating the farmers about controlled burning could help to reduce forest fires occurrence.

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