VISUALISING URBAN AIR QUALITY USING AERMOD, CALPUFF AND CFD MODELS: A CRITICAL REVIEW

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ABSTRACT:

Degradation of air quality level can affect human's health especially respiratory and circulatory system. This is because the harmful particles will penetrate into human's body through exposure to surrounding. The existence of air pollution event is one of the causes for air quality to be low in affected urban area. To monitor this event, a proper management of urban air quality is required to solve and reduce the impact on human and environment. One of the ways to manage urban air quality is by modelling ambient air pollutants. So, this paper reviews three modelling tools which are AERMOD, CALPUFF and CFD in order to visualise the air pollutants in urban area. These three tools have its own capability in modelling the air quality. AERMOD is better to be used in short range dispersion model while CALPUFF is for wide range of dispersion model. Somehow, it is different for CFD model as this model can be used in wide range of application such as air ventilation in clothing and not specifically for air quality modelling only. Because of this, AERMOD and CALPUFF model can be classified in air quality modelling tools group whereas CFD modelling tool is classified into different group namely a non-specific modelling tool group which can be implemented in many fields of study. Earlier air quality researches produced results in two-dimensional (2D) visualization. But there are several of disadvantages for this technique. It cannot provide height information and exact location of pollutants in three-dimensional (3D) as perceived in real world. Moreover, it cannot show a good representation of wind movement throughout the study area. To overcome this problem, the 3D visualization needs to be implemented in the urban air quality study. Thus, this paper intended to give a better understanding on modeling tools with the visualization technique used for the result of performed research.

1. INTRODUCTION

Air quality is considered as one of the main concern by residents in urban areas because it can affect people's health (Dong, Xu, Xu, & Xie, 2019). The high concentration of particles that exist in the surrounding air of urban area such as nitrogen oxide (NO), carbon dioxide (CO_2), ozone (O_3) and other harmful gases are the main contributors to health problems experienced by human during pollution event. Some of the diseases that are associated with air quality problem are asthma, low birth rate, lung cancer and ventricular hypertrophy (Ghorani-Azam, Riahi-Zanjani, & Balali-Mood, 2016). As stated by WHO (2018), these diseases are exposed to human because the particles are micro-sized which can easily penetrate into respiratory and circulatory system and consequently can damage heart, brain and lungs.

Air pollution can be controlled when there are no excess release of gases as stated above but with the development of technology and the need to move from one place to another, it is somehow hard to be controlled. One of the source of pollution is because of road traffic. When there are too many cars or vehicles on the road at the same time, it causes the increase amount of CO_2 and NO (Çeliktaş et al., 2019). Air pollution is not only occurs because of heavy traffic, instead there are many other reasons of the occurrence which are open burning (Guan, Chen, Cheng, Yan, & Hou, 2017) and fuel combustion (Jiang, Mei, & Feng, 2016).

The urban air quality is measured to assess the air status. It is important as it can specify whether the air is safe for people to breathe in or there is a need to wear a mask. If it is not safe, then people are exposed to health problem related to air quality as mentioned before. Because of this problem, Malaysian Department of Environment (DoE) has formulated a guideline on air quality namely as Air Pollution Index (API) (Abd Rani, Azid, Khalit, Juahir, & Samsudin, 2018). API value can be categorized into five different groups which are 0-50 for good, 51-100 moderate, 101-200 represents unhealthy, 201-300 for very unhealthy condition and over 300 represents hazardous.

API value can help people to know the air quality status of an area roughly as it only represented by value. In this paper, some information regarding mapping or modelling air quality will be provided. Modelled air quality helps in better visualizing the air quality in which in this paper, it is more focusing on existing air quality model. Hence, to further explain, this paper will be divided into four sections. The first section (Section 2) will be explaining about related works on generating air quality model by using existing model. Section 3 will be on the methods performed in preparing this review paper. The next section which is Section 4 discusses on the models involved and comparison with each other while the fourth section will relate the air quality topic with three-dimensional (3D) visualization. Last but not least is the final section which is giving recommendations to improvise air quality related research.

2. RELATED WORKS

Publications related to air quality topic cover a large scope. There are numerous researches that explore on this topic. As it cover on vast range of areas, there are many different subtopics are included.

Some researchers focus on studying the effect of air quality or air pollution events. Anderson et al. (2012) specifically explain on the effect of air pollution that is caused by particulate matter (PM) on human health such as on respiratory and cardiovascular system. For instance, disease that can relate to respiratory system problem is tuberculosis (TB) (Huang et al., 2020). Except for outdoor air pollution as researched by Anderson et al. (2012), indoor air pollution event can also resulted into the same health problem (De la Sota et al., 2018). Air pollution event not only has impact on human health but also on animal life and environment where the animals will experience reproductive problem and in some serious cases, it will extinct. Also, climate changes, acid rain and temperature inversion are the examples of environmental impact from this event (Ghorani-Azam et al., 2016).

Meanwhile, some of the researchers explain on the main reason for air quality degradation to occur for example haze event. According to Pei, Yan, Chen, & Miao (2020), haze event that occurs in Beijing during winter season is because of climate variability and anthropogenic emissions. Figure 1 below shows the impact of climate variables and anthropogenic emission on haze intensity. The effect of climate variability shows a greater impact on air quality problem compared to anthropogenic emissions.

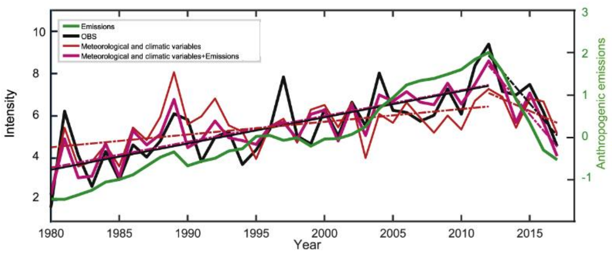

Figure 1. Value of haze intensity as depending on meteorological and climate variables and anthropogenic emission in time series representation (Pei et al., 2020)

Relatively high humidity and low wind speed help the accumulation of pollutants in affected area during this cold season (Gao et al., 2015). Besides, in case of smoke haze event in Indonesia specifically in Riau province of Sumatera, the reason for it to happen is coming from forest and land fires (Kusumaningtyas & Aldrian, 2016). On the other hand, traffic congestion can also contribute to air pollution problem as the vehicles emitted SO_2, NO_2, O_3 and CH_4 to the atmosphere (Chaichan, Kazem, & Abed, 2018).

Also, there are researchers who cover mainly on the ways to model air quality where some of them are focussing on planning purposes while the others focus on monitoring purposes. Based on a research by Macêdo & Ramos (2020), AERMOD dispersion model is used to model air quality in Aracaju, Brazil for the monitoring use of ambient pollutants concentration of the city.

Figure 2. Modelling of 8 hours of CO concentration by using AERMOD dispersion model in the city of Aracaju (Macêdo & Ramos, 2020)

Instead of monitoring air pollution in a city, AERMOD can be used in analyzing distribution of exhaust emission in Gas Turbine Power Plant (Zakaria, Aly & Annisa, 2020) as it is also includes gases such as SO_2, NO_2, CO and particulate matter (PM). CALLPUFF is another example of air quality model that can be an alternative for AERMOD to model power plant emission and also used in modelling gases emission from oil refinery process (Shubbar, Lee, Gzar, & Rood, 2019). Aside from AERMOD and CALPUFF, CFD (Kwak, Baik, Ryu, & Lee, 2015; Rivas et al., 2019) can also involve in modelling air quality.

Thus, in this section, related works that been reviewed was carefully described to show the different aspect each researcher want to focus on their own research related to air quality and air pollution. But, in this review paper, the only subtopic that will be further explained is on air quality modelling.

3. METHODOLOGY

The methodology of this paper starts with Phase 1 which are conducting literature review and analyzing journal articles, reports, book chapter, conference proceedings and online resources that are related to air quality model as in flowchart below (Figure 3).

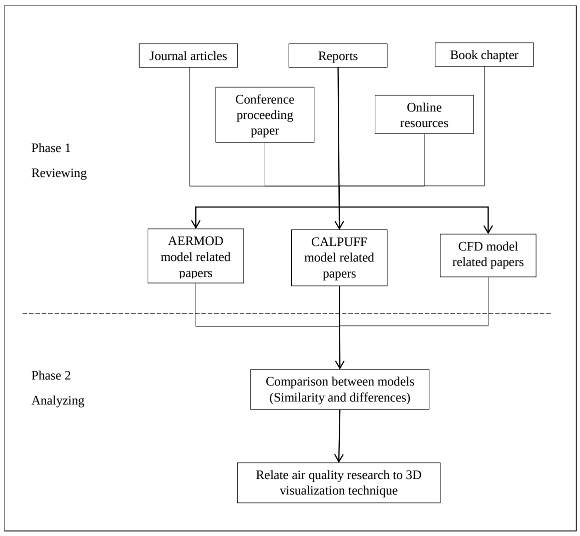

Figure 3. Flowchart of steps involved in writing and preparing review paper on air quality modelling

The first step is reviewing all related documents that are helpful in preparing this review paper. Then, classify each document into three different groups which are AERMOD, CALPUFF and CFD. These groups are determined based on three different air quality modelling tools and system that commonly found in air quality related research. The final step is comparing all the models to see the similarity and differences between them and relate these air quality topics to 3D visualization.

Through reviewing the documents, there are issues that need to be highlighted. The first issue is the comparison between these three models. These models are capable of modelling air quality but there is a clear difference between them. Most of the researches proposed a single model to solve their research question. So, by only referring to a single paper or research, readers cannot differentiate and make comparison between the methods or model. Instead, the good thing is that they provide their chosen model's advantages and ability to perform modelling. Next or the final issue is focusing on CFD modelling tool. CFD model had been applied in many types of research such as air pollution, air ventilation in clothing and others. Thus, the capability of CFD model to be classified as an air quality modelling tool is still questionable. Further discussion regarding this matter is elaborated in Section 4.4.

4. DISCUSSION ON AIR QUALITY MODELLING

4.1 AERMOD

AERMOD is utilized for modelling atmospheric dispersion using Gaussian plume distribution (Idris et al., 2019). It was developed in the 1990s by United States Environment Protection Agency (US EPA) Regulatory Model Improvement Committee to generate a model that is similar to ISC3 (Industrial Source Complex Model) with additional concept of planetary boundary layer (PLC) in order to implement atmospheric stability characterization to the model. Since the development, AERMOD slowly becomes the choice in modelling air pollutants (Macêdo & Ramos, 2020). The model was designed by combining several preprocessors to help in processing the required data (Figure 4).

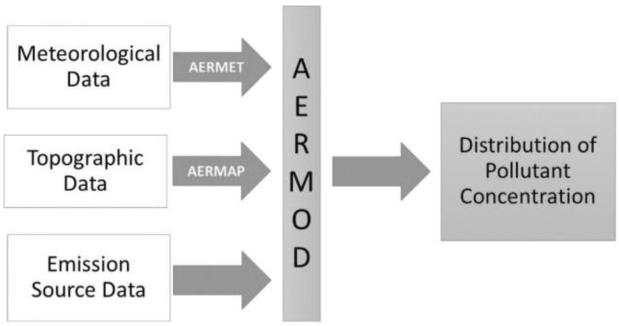

Figure 4. Modelling system of AERMOD with involvement of preprocessor and data (Macêdo & Ramos, 2020)

Figure above shows elements that are needed in performing modelling by using AERMOD. According to Idris et al. (2019), there are two preprocessors involved namely AERMET and AERMAP. AERMET is used to calculate parameter of boundary layer (important in estimating profiles of wind, turbulence and temperature) with the help of acquired meteorological data. Figure 5 shows the wind rose plot that can be generated based on meteorological data.

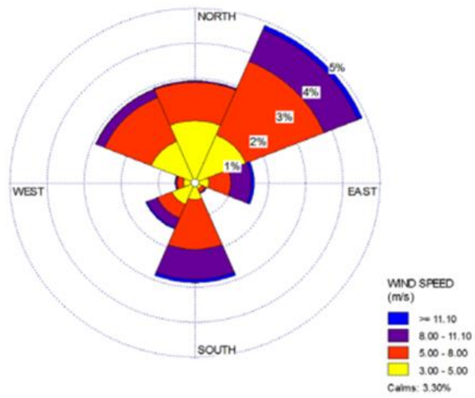

Figure 5. Wind rose plot represents the wind speed values in an area which shows the dominant wind in the northeast region (Fadavi, Abari, & Nadoushan, 2016)

WRF which stands for Weather Research and Forecasting Model is one of the options to get meteorological data. This model needs to be compared with observed data for selected study area to make sure the model is ready to use in AERMOD environment and also for model evaluation (Afzali, Rashid, Afzali, & Younesi, 2017). For the purpose of model evaluation, two important parameters are required to be computed which are RMSE (Root Mean Square Error) and MAE (Mean Absolute Error). Equations involve are as in Equation (1) and (2);

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (O_i - P_i)^2} \quad (1)$$

$$MAE = \sum_{i-1}^{N} |O_i - P_i| / N \quad (2)$$

where O_i is observed value and P_i is the predicted value and N is the total number of observations data. Values can be from temperature reading, wind speed data or wind direction.

Also, AERMET has an ability to pass all the meteorological observation to the main model (AERMOD). Next is AERMAP preprocessor. The function of AERMAP in this model is to compute terrain-height of modelled area. This AERMAP preprocessor will determine the ground altitude beneath all the sources, receivers and height scale of every receiver that can influence the pollutants distribution value (Fadavi et al., 2016). Topographic data such as Digital Elevation Model (DEM) data is required to help processing work for this preprocessor. The combination of AERMAP, AERMET and emission data are supporting the generation of air quality model from AERMOD.

Hence, the use of AERMOD can be found in many air quality related research. One of it is using AERMOD for air quality prediction (Ma et al., 2013). The main element needs to be taken into consideration when performing this type of research is the influence of meteorological data in the future as it involves prediction process. The influence should be insignificant to get a good modelling result. This is because differences in the value of data used can affect the modelling accuracy. Besides, air quality monitoring is (Macêdo & Ramos, 2020) also another example of using AERMOD. In this case, only the significant meteorological data on that specific time of research needs to be considered as this type of research occurs in specific time series with existing measured data.

The product from AERMOD related research especially for air quality can yield a result such as in Figure 6. As in the result, the value of total suspended particulate is represented by range of colors which is depending on the height of research area (contour line). No vertical dimension data is involved in this model. So, this model shows two-dimensional (2D) representation of particles only. Besides the result in Figure 6, a research by Katika & Karuchit (2018) also shows generated model of air pollutants (particles) in the same dimension (Figure 7).

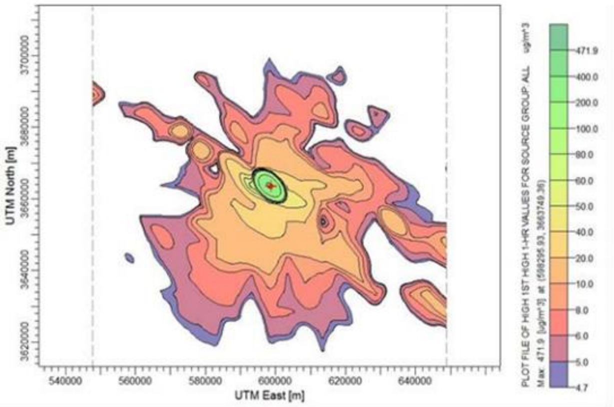

Figure 6. Total suspended particulates (TSP) distribution model generated from AERMOD modelling tool based on contour line (Macêdo & Ramos, 2020)

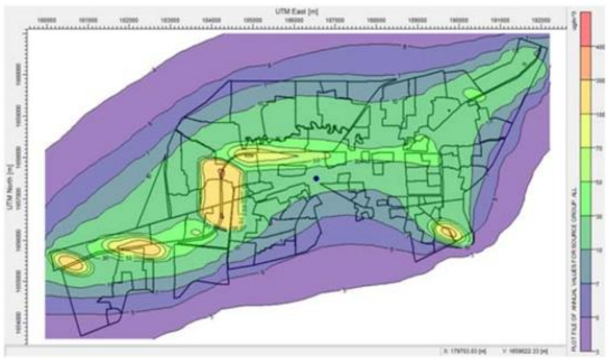

Figure 7. Map of concentration of nitrogen oxide produced from AERMOD (Katika & Karuchit, 2018)

4.2 CALPUFF

According to Rood (2014), CALPUFF is a Lagrangian model that simulates pollutant transport, transformation and deposition in a three-dimensional spatially and temporally variable wind field. This model can be implemented either on local or regional scales. CALPUFF Modelling System consists of three components which are CALMET, CALPUFF and CALPOST. Each components have their own functions where these functions will support each other to generate a good air quality model.

As for CALMET, it functions as a meteorological model which handles on wind and temperature data (Scire et al., 2000) or in some cases, Weather Research and Forecasting (WRF) output file can be used as a reference for meteorological field (Mocerino, Murena, Quaranta, & Toscano, 2020). Another data involve in CALMET are surface characteristics, dispersion properties and mixing height. Next is CALPUFF. This component acts as a transport and dispersion model where it will transfer material that was emitted by modelled sources, perform simulation of dispersion and transformation throughout the whole process involved in CALPUFF. The process results in a file with hourly concentration or hourly deposition fluxes for specific location. This file will further process by CALPOST. CALPOST is also used to process simulation where the result can be represented in table form and identify mean concentration at receptor (Atabi, Jafarigol, Moattar, & Nouri, 2016; Scire et al., 2000). Other than these three components, there are other elements that are associated in CALPUFF Modelling System such as KSP particle model, CALGRID photochemical model and PRTMET postprocessor (Figure 8).

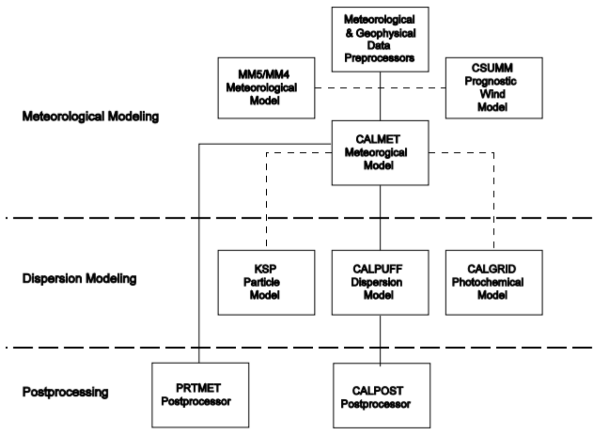

Figure 8. Overview of the whole CALPUFF Modelling System with additional of other related models (Scire et al., 2000)

This CALPUFF Modelling System is another popular choice for the researcher to model air quality. It can be applied to evaluate emission of particles in the atmosphere. For instance, using all related information regarding to power plant including estimated ambient emission rate of SO_2, NO_X and PM and data on the surrounding wind from NOAA's Rapid Update Cycle (RUC2) model (Levy, Spengler, Hlinka, Sullivan, & Moon, 2002). These data will support the production of gases emission from power plant model with implementing it into CALPUFF model. For another scope of research on air quality, this model is used for air quality monitoring. As stated in research by (Mocerino et al., 2020), CALPUFF model is applied on air quality monitoring of port area. Hence, the data needed are traffic data of ship passenger (used to estimate pollutants (SO_2 and NO_2 emission) and meteorological data. It is the same as the earlier application where these data will be fed into CALPUFF system then during the final process, air quality model will be generated.

By using CALPUFF model, the generated model of pollutants or gases can be viewed as shown in Figure 9. This model presents particles concentration in 2D visualization which including the coordinate of study area, height of study area (represents by contour line) and concentration of researched particle (nitrate). With this information, reader can get information regarding to different concentration value of pollutants on different height of study area. Besides, Figure 10 also provides an example of result from study related to air quality where one of the pollutants that was investigated is SO_2.

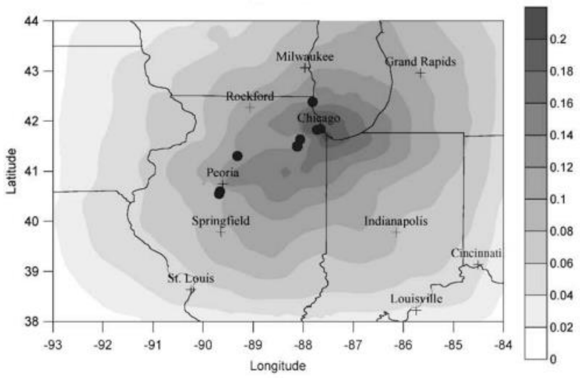

Figure 9. Annual concentration average of particulate nitrate in Illinois area mapped by using CALPUFF model (Levy et al., 2002)

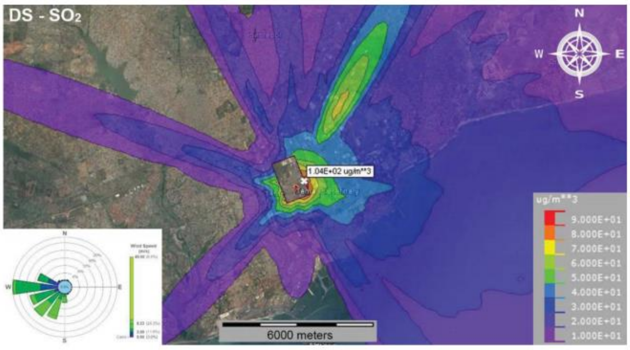

Figure 10. Dispersion map of SO_2 emission from CALPUFF dispersion model over real world map on study area of Tema Metropolis in Ghana (Amoatey et al., 2019)

4.3 CFD

CFD model stands for Computational Fluid Dynamics model. It was developed because of the development of computers and simulation of CFD. As defined by Hu (2012), CFD is a science that produces predictions of fluid-flow phenomena based on conservation laws quantitatively. The predictions that perform through this model occurs as per determined by flow of geometry (ANSYS Workbench is one of the software that can be chosen to prepare the geometry flow (Khatri, Khare, & Kumar, 2020), physical properties of fluid and the condition of field of flow. As explained in the definition and with some description, it can be concluded that this model is specifically used as a tool to analyze fluid-flow events or problems.

CFD model can be applied in wide range of application. According to Amorim, Rodrigues, Tavares, Valente, & Borrego (2013), this model is implemented in a study on evaluating the impact of urban trees on CO dispersion. Data such as meteorological data (wind velocity and wind direction), data on coordinates of elements involved and traffic emission data are the main data needed in supporting the modelling tools. This model is associated to outdoor air pollution. CFD model not only can be used for outdoor but also for outdoor air pollution. So, as researched by Yang, Ye, & he (2014), indoor environment of a room or house with existing air condition is analyzed by using CFD model to determine pollution level inside. For this purpose, temperature, wind velocity and air age field were collected and later applied in this model. Apart from air pollution related analysis or research, this CFD model can be applied on non-air pollution field too. For instance, this model can be used to analyze the air ventilation in clothing (Choudhary, Udayraj, Wang, Ke, & Yang, 2020).

As CFD modelling tool can be included in many fields, so there will be different types of results can be obtained from the study that utilize this model. For example, for study related to air quality monitoring, carbon monoxide (CO) concentration surrounding the building will be mapped in 2D representation by using data such as coordinates of study area, contour line from digital elevation model (DEM) and the concentration values themselves (Figure 11). Apart from this, non air quality research by Choudhary et al. (2020) somehow shows a quite different result where the result is in 3D representation (Figure 12). This is because there is one important element implemented within this CFD model environment that is 3D body scanning data. With this, it can support to generate result in 3D visualisation.

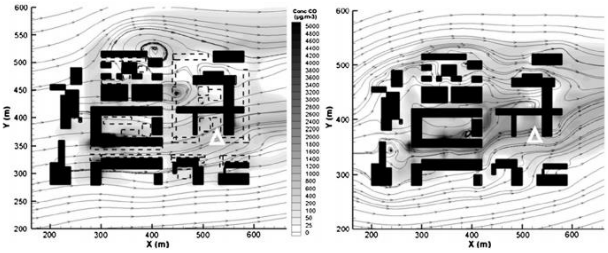

Figure 11. CFD model generated result of CO concentration with and without the presence of trees surrounding the building in Aveiro (Amorim et al., 2013)

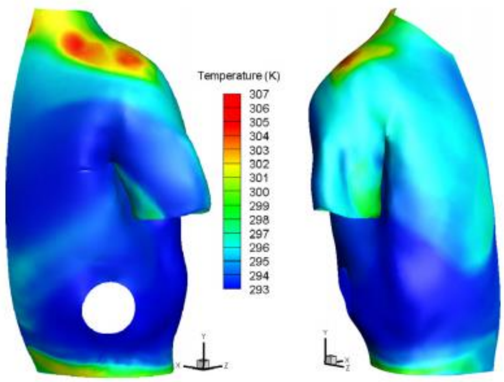

Figure 12 . Temperature distribution with representation of color from blue to red to show the coolest to hottest area in air ventilation jacket (Choudhary et al., 2020)

4.4 Comparison between the models

AERMOD and CALPUFF models can be classified as a group of models specifically for air quality modelling meanwhile CFD model is classified into another group which is a modelling tool that is not only for air quality modelling. This is because AERMOD and CALPUFF are models that are used specifically for analyzing and investigating air pollution related problem but for CFD model, this model can be used in wide range of application without only specializing in solving air pollution related matter. Because of this, AERMOD and CALPUFF are categorized into air quality model group but as for CFD model, it is not accurate to classify it into the same group. Instead, it can be clearly explained as a model that can be used in modelling air quality but this is not the only ability for this model to perform. So, CFD can be classified in another group named as modelling tools.

	AERMOD	CALPUFF	CFD
Class	Air quality modelling tool	Air quality modelling tool	Non-specific class of modelling tool which can be used in many fields of study
Components/ pre-processor involved in modelling tool	- AERMAT - AERMAP	- CALMET - CALPUFF - CALPOST	No specific component needed
Dimension of visualisation supported	2 Dimension	2 Dimension	-2 Dimension -3 Dimension
Range of dispersion model	Suitable for short range dispersion model (<50km)	Suitable for wide range dispersion model (>50km)	Both short and wide range dispersion model

Table 1. Summary of comparison between AERMOD, CALPUFF and CFD modelling tools

There is another similarity between these modelling systems except for its main function, that is modeling air quality. The similarity can be found from the components required to perform the modelling. For instance, both models implemented their own subcomponents to facilitate and support the modelling tools. As for AERMOD, the components are AERMAT and AERMAP meanwhile for CALPUFF are CALMET, CALPUFF and CALPOST. The importance of these elements are to make sure each specific workflow can be done separately from others and do not affect other processes. Besides, both models can support 2D visualisation of pollutants concentration specifically when dealing with air quality related research. But, it is different for CFD model. When this CFD model is integrated with 3D data for example as in earlier study related to air ventilation jacket, the final product will show obtained and studied data in 3D representation.

Although AERMOD and CALPUFF are in the same class which have the ability to model air quality, but there is still a difference between these models. The difference can be obtained from the range of dispersion model to be generated. AERMOD is suitable to be used for short range dispersion model while CALPUFF is for wide range dispersion model.

5. 3D VISUALIZATION

3D visualization is a method used to present or show any results or models or anything related in 3D representation (see Yusoff et al., 2011; Azri et al., 2018; Ujang et al., 2015). 3D geometrical data contains three axes which are x-axis, y-axis and z-axis. The existence of these axes are important to differentiate between 2D and 3D data. This is because data with 2D representation happens to be in x and y-axis only. 3D visualization can be seen in many fields and one of it is in Geographic Information System (GIS) field. GIS is defined as computer-based system that is used to capture, store, retrieve, analyse and display spatial data (Skidmore, 2017). The use of two-dimensional data in GIS can be seen in many applications, ranging from storing spatial data to select the best site location based on multi-criteria analysis (Mohd et al., 2016). On the other hand, the definition of 3D visualization for general application and GIS field are the same. But the different is the data used in visualization which is the spatial data. Only GIS-related data is needed and involved. Examples of data that can be used are 3D model of building (Figure 13), raster and vector file of data (Dell et al., 2016) such as road and river.

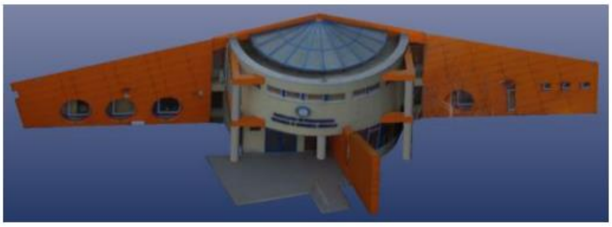

Figure 13. 3D model of a building generated from Unmanned Aerial System (Oniga, Chirilă, & Stătescu, 2017)

The need to visualize air quality in 3D is because of the disadvantages portrayed by 2D visualization. The first disadvantage comes from 2D visualization is in term of dimension itself. 2D model has one axis lesser compared to 3D model. With this disadvantage, visualization in 2D cannot provide height information and exact location of pollutants clearly to reader. This is because by using for example contour line, the height of location can be determined but the exact location at the specific height cannot be informed directly without referring to coordinate in the generated map. Next, in visualizing air quality, the important factor needs to be taken into consideration is the wind movement used for air pollutants travel. By using 2D visualization, it cannot show a good representation of wind movement throughout the study area. This wind movement is necessary as it can show how air pollutants travel in that area and it can be used in supporting the process for determining the pollutants in an accumulated area. When the accumulated area can be presented, then one can easily define the place that has the highest chance for people to be exposed to the air quality related disease. Lastly, many researchers use contour line (Amoatey, Omidvarborna, Affum, & Baawain, 2019; Katika & Karuchit, 2018) as to represent concentration of pollutants in the study area. The disadvantage of using this method is that not all locations in study area with the same height have the same pollutants concentration. This is caused by the effect of the existence of natural objects such as hill, mountain and tree and also because of man-made features such as building and bridge. So, with 3D visualization, it can help in providing better presentation of pollutants concentration at specific locations without having to refer to height provided by contour data.

By relating this visualization technique with the air quality models, it is possible for this technique to be implemented in air quality related research. But many researches only produce 2D representation of result for instance, 2D representation of SO_2 concentration (Amoatey et al., 2019) and nitrogen oxide (Katika & Karuchit, 2018) of study area. On the other hand, a research such as from Choudhary et al. (2020), yields result in 3D visualization but this research is not focusing on air quality related instead it is more on air ventilation in clothing. The difference between these mentioned researches is the data used in which one is integrated with 3D data but the others are implemented with 2D data only. So, there is still a lacking element in air quality study where the results for the studies are still in 2D representation.

In order to implement 3D visualization into air quality related research, the integration between the modelling tools which are AERMOD, CALPUFF and CFD with 3D data is a must. For instance, without the height data of a place, no height information can be presented (which is used for z-axis) and at the same time, mapping on 3D platform cannot be done. So, modeling tool and data need to undergo simulation process together to obtain result of study in 3D visualization. Example of data that can be used in obtaining such result for example in urban area is 3D model of building in that selected urban area (see Azri et al., 2014).

6. RECOMMENDATION

There are a lot of existing air quality related researches, but there are some parts that can be added or improvised to get variety of different results and findings that can solve many different problems at the same time. In some existing research, in order to model air quality, they only used pollutants concentration information, climate data and other data that are needed in modelling tools. All of these data are important and required in modelling but as the main reasons for modelling to be done is to evaluate and map the pollutants concentration of specific area, there is another important matter that need to be taken into consideration. It is the existence of tree. The existence of tree can reduce the pollutants concentration in the air but this statement is still questionable. So, the effect of tree existence also need to be measured correctly as to determine the exact amount of pollutants concentration that exists because of haze, heavy traffic and so on. With the exact value obtained, suitable action can be suggested to overcome the problem.

Besides, different areas of study can be considered to be chosen. Usually, urban area is chosen as a research area for haze study but for further research, residential area can be selected as the area of study. This is because haze is dispersed by the wind so there is no specific chosen area for it to travel. Also, during haze event, people are advised to stay home and limit their movement to avoid from being exposed to harmful pollutants coming from haze. Hence, with this type of study, the obtained result can help to inform residence on the accurate status of air quality.

As to perform both recommendations, it is good and better to integrate it with 3D model. The advantage of integrating with 3D model is that the users or any other responsible agency who view the result can have a better understanding of the product. With 3D model, not only the statistics of pollutant concentration can be viewed but also the exact location of the pollutants. Moreover, with 3D modelling, vertical and horizontal dimension of study area is used for analysis and viewing purposes (see Ujang et al., 2015). It is necessary to make people understand and visualise the output of pollutant concentration at the study area. In addition, based on this information, responsible agency or authorities can plan and make decisions to solve the pollutants problem on a smaller scale. Furthermore, advanced 3D spatial analysis could be done as suggested by other researchers (Yang et al., 2020; Azri et al., 2016; Salleh et al., 2018; Keling et al. 2017)

7. SUMMARY

This paper provides a review on modelling tools and system that can be used in air quality modelling related research. Three different models (AERMOD, CALPUFF and CFD) have been reviewed and further described on the definition and application that are associated with the models. These models have the same ability in which is as the title of this review paper, the models can model air quality but CFD has additional ability in modelling any others application related to fluid-flow. Besides, there is a lacking ability in air quality modelling which is visualizing result in 3D representation. This can only be solved by integrating 3D data in processing workflow. In addition, 3D urban spatial data can be clustered to allow for a deeper understanding of the subject (Azri et al., 2015; Puspitasari et al., 2020). On the other hand, through the process of preparing this paper, some issues have been encountered regarding to different models used in air quality study and the ability of CFD model. The issues can be solved by performing comparison process between the selected models especially in terms of the ability to perform modelling. Accurate and suitable model can be resulted into a better product for the research. Thus, with this paper, one can get a better understanding on model that can be implemented and the visualization technique used in air quality field.

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