PROCEEDINGS OF THE NATIONAL SEMINAR ON SCIENCE AND ITS APPLICATION IN INDUSTRY

(SSASI 2006)

PREFACE

The National Seminar on Science and Its Application in Industry (SSASI), sought to strengthen the ties between science, engineering, industry and society. Our hope with these proceedings is that you will feel stimulated by the new and different ideas that would help everyone. The papers in these proceedings have been divided in the following sections in order to open ourselves to a broad spectrum of science, with the following: Physics, Chemistry, and Biotechnology; Applied Mathematics and Statistics; Industrial design and Innovation; and Industrial Technology and Engineering.

The Seminar came in response to the public support for science and technology which is ever expanding. Besides, scientific research and technological development have become more necessary than ever to solve some of the pressing problems faced by us.

This Seminar calls for a new commitment, a new social contract, whereby academics pledge to be responsive to the industries' needs and governments continuous support for rese... and development, especially in Physics, Chemistry and Biotechnology.

The ...ceedings on Applied Mathematics and Statistics focused on current research, the..., issues, classroom applications, developments, and trends related to the app...ion of these disciplines in industries.

This Seminar provides a basis for an on-going reflection and discussion of the Seminar's themes and issues in this field. It provides an avenue for a standard reference, publishing seminar papers as well as the latest theoretical results and reports on practical applications of Applied Mathematics and Statistics.

Industrial design and Innovation continues to develop rapidly and becoming important in many aspects of our lives. Thus SSASI, features multidisciplinary studies and provides opportunities for exchanging research results across a wide range of fields in Industrial design and Innovation. The Seminar serves as an important platform for all specialists and related people in Industrial design and Innovation, to share knowledge and enhance further the fast moving industry.

The increasing complexity of industrial technology and other engineering constraints have imposed a real challenge on the rapid development of industrial technology. This Seminar looks at the advances in technology as well as the increasing pace of changes in market needs and customer requirements. Such changes while cannot be avoided; their impact on the technological development should be carefully studied. The motivation of this Seminar is to investigate and balance both the theoretical and practical aspects of Industrial Technology and Engineering developments.

Through SSASI, academics and experts in Industrial Technology and Engineering are able to put forward the new developments and needs in this field, in order to create a niche market.

All the articles in the proceedings are expected to fulfill the needs to sustain the industries in a vibrant and fast moving pace, through collaboration and partnerships.

We hope this Seminar will succeed in its aim of fostering closer mutual ties between the scientific fraternity, industry and society at large. It is expected that a better awareness of each other's needs and expectations will evolve by sharing each others' expertise and experience. This Seminar, also, hopes to pave way for the orientation of science towards sustainable human development and better management of the environment.

- A -

PHYSICS, CHEMISTRY AND BIOLOGY

SATELLITE-BASED METHOD FOR COMPUTING AIR POLLUTION INDEX

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Abstract:
T... recent August 2005 haze episode was not a new experience for Malaysia as this phenomenon has been o... ing almost every year. History revealed that the worst haze episode took place during May-November 1... On the 23rd September 1997, the Sarawak capital, Kuching was declared in the state of emergency as its A... llution Index (API) reached 839. This was the highest API ever been recorded in Malaysia. This paper r... s result of a study in order to compute API using satellite-based method. Seven dates of NOAA-14 A... R satellite recorded data were used, representing seven days during the September 1997 thick haze episode in Malaysia. Five locations of air pollution station were selected where major pollutants have been measured conventionally. Haze information was extracted from the satellite data using 'sky-light' model. Relationship between the satellite recorded reflectance and the corresponding pollutant measurement was determined using regression analysis. Finally, accuracy of the result was assessed using RMSE technique. The result proven that satellite-based method using space-borne remote sensing data was capable of computing API spatially and continuously.

Keywords:
PM 10, NOAA-14 AVHRR, AQI, GIS

1 Introduction

Haze is said to be a partially opaque condition of the atmosphere caused by very tiny suspended solid or liquid particles in the air (Morris, 1975). Haze (originating from open burning or forest fire) usually contains large amount of particulate matter (e.g., organic matter, graphitic carbon). This particulate matter is hazardous to health, especially associated with lung and eye deceases. Besides that it is capable of reducing visibility, increasing the atmospheric greenhouse effects and affecting the tropospheric chemistry.

Coventionally, PM 10 can be measured from ground instruments such as *air sampler*, *sun photometer* and *optical particle counter*, however these instruments is impractical if measurement are to be made over relatively large areas or for continuous monitoring.

The haze episode which occured during mid-May to November 1997 is considered the worst since 1980 (five similar haze episodes had occured in April 1983, August 1990, June 1991, October 1991 and August 1994). On 19th September 1997 Malaysian government had declared that Kuching (capital of Sarawak) was in the state of emergency when the PM10 API (Air Pollution Index) exceeded 650 (hazardous level). By 23rd September 1997 the condition worsened as Kuching's PM10 API reached 839, the highest ever been recorded by the country.

This paper reports results of a study to determine PM 10 from NOAA-14 AVHRR satellite data. Their concentration and spatial distribution will be quantified based on updated measurement system, AQI. This current study is an extension of previous work by Ahmad and Hashim (1997, 2000, 2002), and mazlan et. al (2004) that produced models to quantify haze in API.

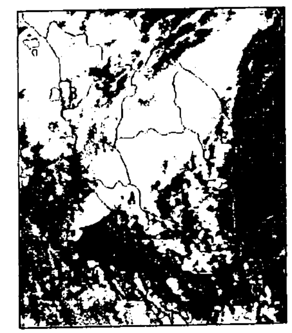


Figure. 1. Raw NOAA AVHRR data dated 22 September 1997. Location of the selected air pollution stations are damarcated as letter A,B,C,D and E designated for Kuala Lumpur, Prai, Pasir Gudang, Bukit Rambai, and Bukit Kuang respectively. Combination of band 1, 2 and 4 are used to visually differentiate between haze (orange), low clouds (yellow) and high clouds (white).

2 Materials

This study involved the usage of three types of data namely; ground-truth data, satellite data and ancillary data.

2.1 Ground-truth data

Conventional measurements of haze were complementarily used throughout performing data processing for extraction of PM 10 information. PM 10 measurements in micrograms per meter cube (μgm^{-3}) from 1st to 30th September 1997 were carried out by ASMA (Alam Sekitar Malaysia Sdn. Bhd.) to represent the actual haze intensity over the study area. For the purpose of this study, the measurement was later converted to AQI.

Table 1. Air Quality Index (AQI) for Particulate Matter up to 10 micrometers in diameter (PM 10)

Index Values*	Levelsof Health Concern	Cautionary Statements
0 - 50	Good	None
51 - 100	Moderate	None
101 - 150	Unhealthy for Sensitive Groups	People with Respiratory disease, such as asthma, should limit outdoor exertion.
151 - 200	Unhealthy	People with respiratory disease, such as asthma, should avoid outdoor exertion; everyone else, especially the elderly and children, should limit prolonged outdoor exertion.
201 - 300	Very Unhealthy	People with respiratory disease, such as asthma, should avoid any outdoor activity; everyone else, especially the elderly and children, should limit outdoor exertion.
301 – 500	Hazardous	Everyone should avoid any outdoor exertion; people with respiratory disease, such as asthma, should remain indoors.

*An AQI of 100 for PM10 corresponds to a PM10 level of 150 micrograms per cubic meter (averaged over 24 hours).

2.2 Satellite data

Seven sets of NOAA-14 AVHRR data dated 22, 23, 25, 2, 28, 29 and 30 September 1997 acquired from SEAFDEC (Southeast Asia Fishery Development Centre) receiving station were used. NOAA-14 AVHRR was suitable for haze study as it offers high spectral and temporal resolution with a minimum cost. Some useful characteristics of NOAA-14 AVHRR satellite are shown in Table 2.

Table 2. NOAA-14 AVHRR sensor and spectral characteristics

AVHRR Sensor characteristics

Swath width	2399km
Resolution at nadir	1.1km approx.
Altitude	833km
Quantisation	10 bit
Orbit type	Sun synchronous
No. of orbits per day	14.1 (approx.)

AVHRR Spectral characteristics

Channel No	Wavelength	Typical use
1	0.58 - 0.68	Daytime cloud, haze and surface mapping
2	0.725 - 1.00	Land-water boundaries
3	3.55 - 3.93	Night cloud mapping, sea surface temperature
3A	N/A	Snow and ice detection
3B	N/A	Night cloud mapping, sea surface temperature
4	10.30 - 11.30	Night cloud mapping, sea surface temperature
5	11.50 - 12.50	Sea surface temperature

(Source: Kidwell et al., 1995)

2.3 Ancillary data

Meteorological information over study area, including visibility (Figure 2), air temperature, pressure, relative humidity, wind, etc were obtained from MMS (Malaysian Meteorological Service).

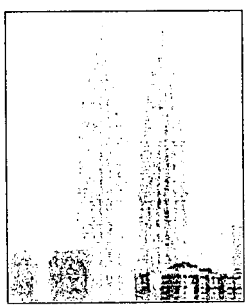


Fig.ure2. Reducing visibility of Petronas Twin Towers resulted from the appearance of haze

3 Method

Three modules incorporated in this study are (1) Derivation of haze model, (2) Regression analysis, and (3) Accuracy Assessment.

3.1 Derivation of haze model

Prior to further data processing, post launch calibration of visible Band 1 NOAA-14 AVHRR was earlier implemented in order to compensate data degradation due to extreme temperature change before and after launching of AVHRR sensor to space (Rao et al., 1996). Clouds and haze were successfully differentiated using thresholding technique (Baum et al., 1997). This to ensure both were not being misinterpreted between each other. Model used in this study is based on Siegenthaler and Baumgartner (1996), which make use of *skylight* to indicate the existence of haze. *Skylight* is an indirect radiation, which occurs when radiation from the sun being scattered by elements within the haze layer. It is not a direct radiation, which is dominated by pixels on the earth surface. Figure 3 shows electromagnetic radiation path propagating from the sun towards the NOAA-14 AVHRR satellite penetrating through a haze layer. Path number 1, 3 and 4 are skylight caused by direct radiation, whereas path 2 is indirect radiation.

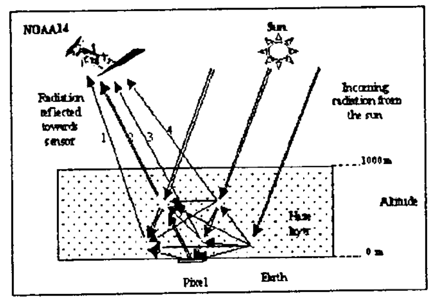


Figure 3. Model used in this study is based on the *skylight* parameter (Source : Modified after Siegenthaler and Baumgartner, 1996)

This model can be described by:

$$\sigma - R = L - V \tag{1}$$

where,

σ	:	*reflectance* recorded by satellite sensor,
R	:	*reflectance* from known object from earth surface ,
L	:	*skylight*, and
V	:	lost radiation caused by scattering and absorption.

3.2 Regression analysis

Calibration pixels of NOAA-14 AVHRR data were sampled within a radius of 2.5 km from each of the air pollution stations. The relationship between PM 10 AQI and satellite-recorded reflectance of band 1 AVHRR, were analysed using linear regression.

3.3 Accuracy Assessment

In order to verify the accuracy of the regression model, RMSE (Root-mean-squared Error) was implemented to the AQI values obtained by the model.

$$RMSE = \sqrt{\frac{1}{n}\sum\left(AQI_{calculated} - AQI_{measured}\right)^2} \tag{2}$$

4 Results

The scatter plot for PM 10 versus satellite reflectance of band 1 NOAA AVHRR with its linear regression trend is shown in Figure 4 where the coefficient of determination, R^2 is 0.5563. The linear regression model can be expressed as:

$$PM10\_Concentration\ (AQI) = (5.174 \times Satellite\_Reflectance) - 77.877 \qquad (3)$$

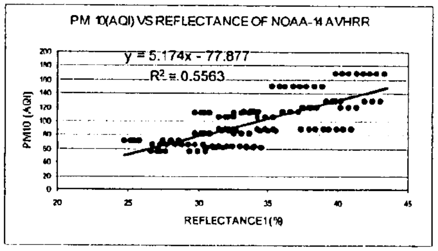


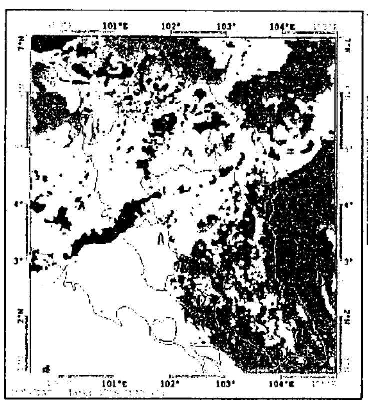
Figure 4. PM 10 in AQI versus satellite reflectance in percentage. Linear regression trend is shown in black line

The RMSE varies accordingly for all the five PM 10 ground stations ranging from 7 to 62 and with the average of 33 (Table 3). It is believed that the relatively high RMSE was due to limited number of air pollution stations used. Future study will consider of using more air pollution stations as well as other value-added ancillary data in order gain better and reliable accuracy.

Table 3. Average RMSE for respective haze components at Penang and Johor Bahru

Location	A	B	C	D	E
RMSE (AQI)	33	35	26	62	7

spatial distribution of PM 10 can be shown in a colourful map (Figure 5) consisting of regions in (good), yellow (moderate), orange (unhealthy for sensitive groups), red (unhealthy), purple (very unhealthy) and maroon (hazardous). Cautionary Statements for every region are given in detail in Table 1.



Colours	Air Quality Index (AQI) Values	Level Of Health Concern
	0 to 50	Good
	51 to 100	Moderate
	101 to 150	Unhealthy for sensitive groups
	151 to 200	Unhealthy
	201 to 300	Very unhealthy
	251 to 500	Hazardous
		Clouds

Figure 5. PM 10 concentration in AQI for 22nd September 1997. The PM 10 level in most area was good and moderate.

5 Discussion and Suggestion

Integration of remote sensing and GIS (global positioning system) technology has been widely used in the field of atmospheric science related to air pollution. Our current and future studies on this field will focus on such integration. Besides that, the usage of 36 air pollution stations (Fig. 6) will increase the accuracy of the result (previously only five stations were used).

Figure 6. Air pollutions stations used in current study

The use of GIS interpolation to map haze based on iso-lines seems to be successful. Some of the outcomes of using GIS to determine spatial distribution of PM 10 have been obtained as shown in Figure 7, 8 and 9.

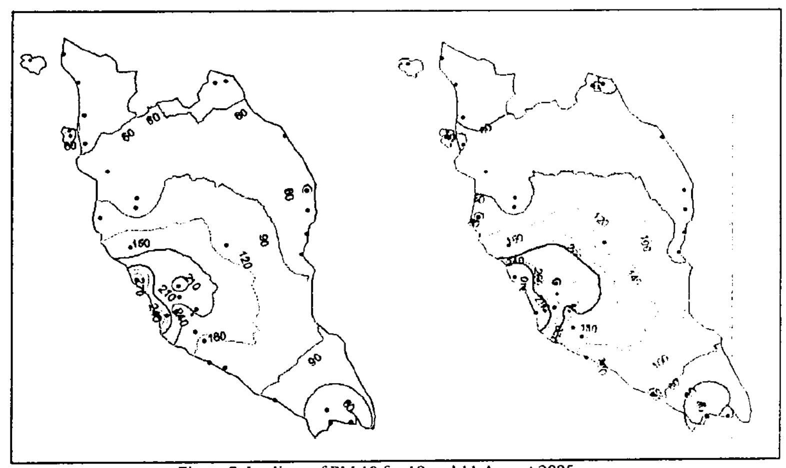


Figure 7. Iso-lines of PM 10 for 10 and 11 August 2005.

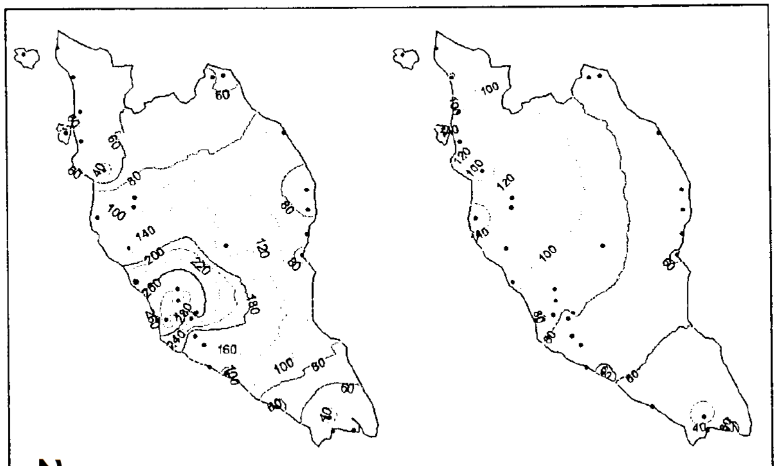


Figure 8. Iso-lines of PM 10 for 12 and 13 August 2005.

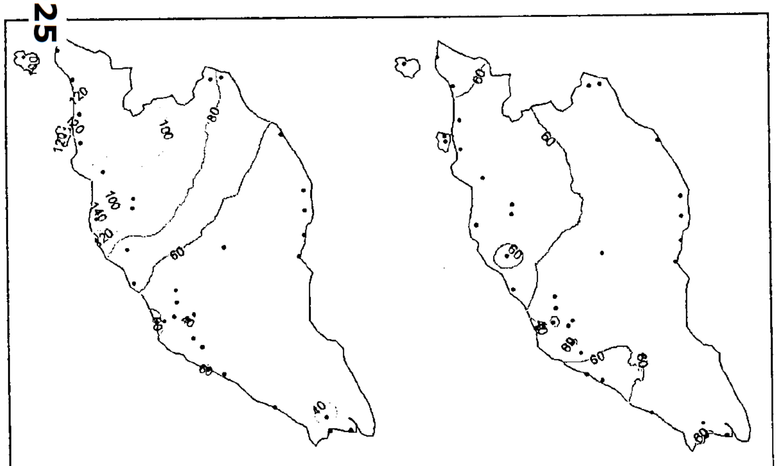


Figure 9. Iso-lines of PM 10 for 14 and 15 August 2005.

Conclusion

The study shows that remote sensing technique is capable of determining PM 10 concentration spatially and continuously with minimum cost and time. These are useful in order to provide haze early warnings, so that necessary measures could be taken effectively by both government authorised party as well as public. The result can further be improved by using integration of both remote sensing and GIS technology. Current progress of using this integration technique has show a promising outcomes.

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