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So near yet so different: Surface ozone at three sites in Malaysia

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Abstract. Surface ozone is an air pollutant and greenhouse gas. This study attempts to identify some key challenges in ozone mitigation based on surface ozone observations at three locations within and near Klang Valley, Malaysia. Surface ozone data obtained from the Department of Environment Malaysia for Petaling Jaya (S1), Shah Alam (S2) and Cheras (S3) stations are analysed to show variation in ozone between stations that are in close proximity. Initial statistical analysis results indicate a large difference in the frequency of total daily maximum ozone concentration at S2 compared to S1 and S3 stations. The application of IoT could likely be a viable option for determining sensitivity to precursors and meteorological conditions once the technology has further matured.

1. Introduction

Surface ozone concentrations have been shown to be relatively high at certain locations in Malaysia when compared against the Malaysian Ambient Air Quality Guideline (MAAQG) of 100 pbb and 60 pbb for 1h and 8h ozone [1-3]. These high concentrations are a cause for concern as ozone has been shown to be detrimental to health as well as reduce crop yields [4, 5]. Mitigating this pollutant is a challenge as it involves complex interaction between precursors that form ozone and scavengers that reduce ozone concentrations as well as meteorological parameters that influence transport and photochemistry [6-8]. The concentration of ozone in many of the urban, suburban and industrial stations in Malaysia have been studied, with the focus mainly falling on the status of air quality, its sources or forecasting applications [9-11]. Given that ozone is a secondary pollutant which requires the presence of sunlight for its formation, identifying sources and making reliable forecasts presents unique challenges. In this study, surface ozone from observations from three monitoring stations located within a 20 km radius from each other is presented to highlight the challenges involved in ozone mitigation.

2. Study area and methodology

The data source is the Department of Environment Malaysia. Three monitoring stations located within Peninsular Malaysia were selected for analysis due to their relative proximity to each other (Figure 1). These stations are located within the west coast of Peninsular Malaysia. S1 and S3 is located within a 10 km radius of S2. Ozone measurements from 2012 to 2014 were measured using Teledyne Model 400A, USA. The wind speed and direction for the period between June to August (JJA) 2014 were measured using Met One 010C sensor (wind speed), Met One 020C sensor (wind direction). The wind rose was plotted using WRPLOT View software Version 8.0.2 (https://www.weblakes.com) which was imported into Google Earth Pro Version 7.3.2.

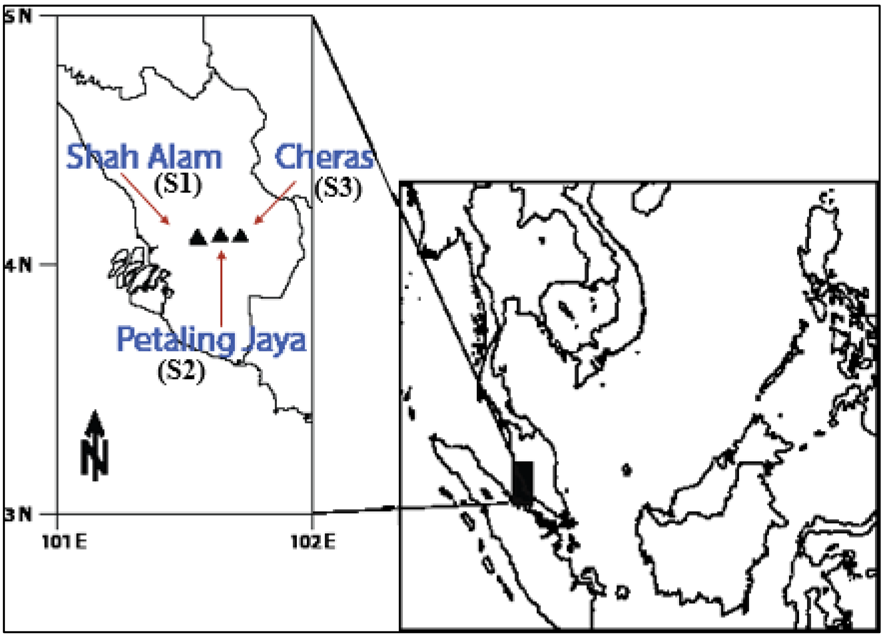

Figure 1. Location of monitoring stations

3. Results and discussion

The Malaysian Ambient Air Quality Guideline for 1h ozone is 100 ppb. The number of times ozone concentration equaled or exceeded this value between 2012 and 2014 is presented in Figure 2. The results indicate much fewer exceedance at S2 compared to S1 and S3. Similar pattern has been observed in short and long-term observations at these locations [1, 3]. The pattern of ozone exceedance between the years also differ between all three monitoring stations although the distance between the stations are less than 10 km apart. One of the likely reasons proposed for the very low exceedance as S2 is its location near a busy intersection that is conducive to ozone titration [1]. However, titration alone does not help explain the difference in ozone exceedance pattern between the years.

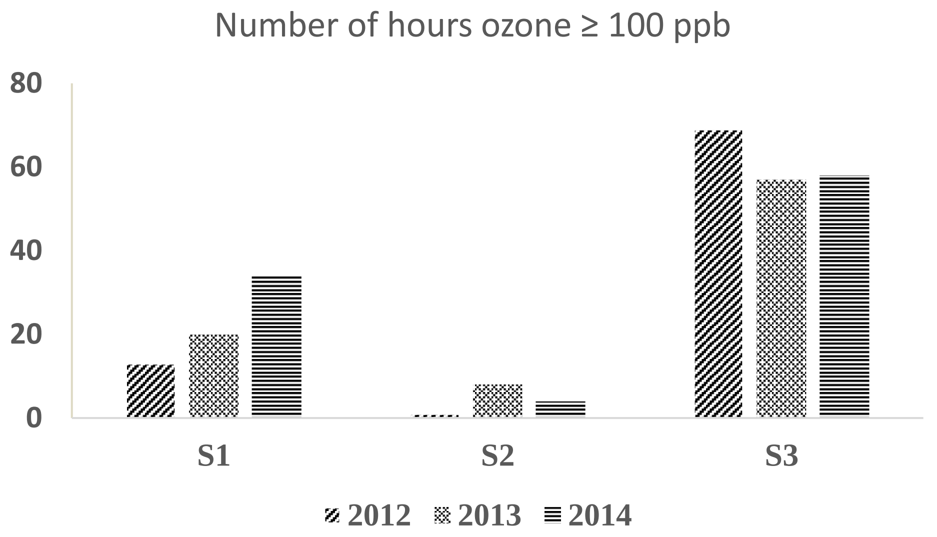

Figure 2. The number of times ozone ≥ 100 ppb at the monitoring stations between 2012 and 2014

To identify the likely influence of meteorology, Figures 3(a) and 3(b) were plotted to compare wind profiles at S2 and S3 during the south west monsoon season. Although the prevalent wind conditions should be the south west direction, near surface measurements (10 m) indicated large difference in the wind profile. Not only is the prevalent wind direction different the period of calm winds was very different as well (2% at S2 and 40% at S3). The land use type (historical) also differ with a much more compact structure and (closer) to major roads at S2 compared to S3.

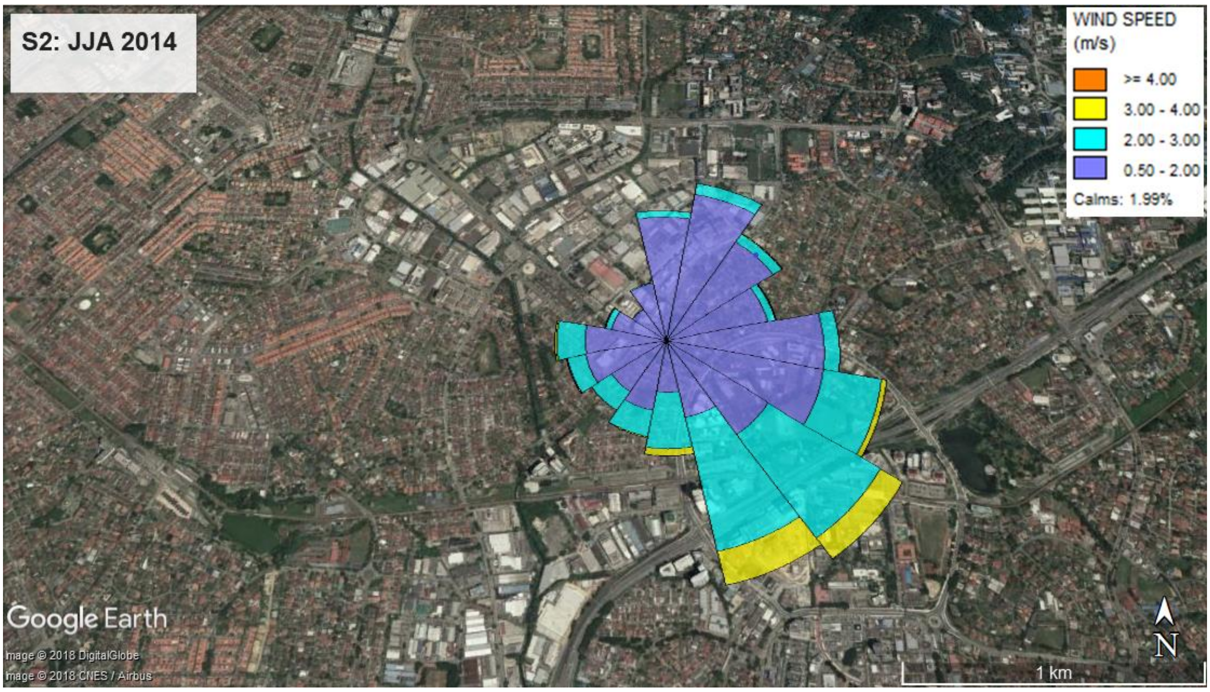

Figure 3(a). Wind rose profile at S2 for the period JJA (2014) and the satellite image at location.

Figure 3(b). Wind rose profile at S3 for the period JJA (2014) and the satellite image at location

Although some of these observation pattern has been highlighted in previous studies, there has not been focused research on the mitigation implication of these observations in Malaysia. If titration of ozone is the predominant factor determining ozone concentration in S2, control strategies involving NOx control would increase ozone in S2. The matter is further complicated by the fact that based on political boundary, S1 and S2 fall under a different local jurisdiction from S3 although S1 and S2 have a closer ozone profile. Even if a blanket policy such as ban on vehicle entry is applied, the effect on ozone is unclear without information on its precursor sensitivity (NOx sensitive or VOC sensitive where NOx represents oxides of nitrogen and VOC represent Volatile Organic Compounds).

4. Way forward

Historical database on ozone and NOx distribution is insufficient to answer some of the questions needed to identify potential effects of specific NOx and VOC control strategies. Further research on ozone precursor (NOx and VOC) control strategies as well as the specific meteorological contribution would be necessary for identifying the best strategy for overall ozone reduction. The challenges in ozone mitigation could also be addressed with the application of Internet of Things whereby citizen scientist function as data providers to provide higher spatial resolution to available measurements and/or parameters previously not measured. Ideally low-cost sensors can be deployed within a grid and the real time measurements be used not only to forecast potential ozone episodes but also provide sufficient historical data to identify best control strategies and monitor the relative success of these strategies.

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