UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL: **CLIMATE CHANGE IMPACTS ON SURFACE OZONE IN MALAYSIA REGION**

IJAZAH: **DOCTOR OF PHILOSOPHY**

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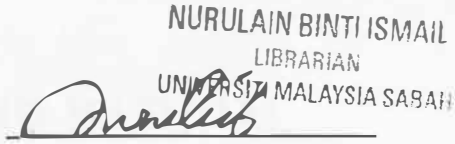

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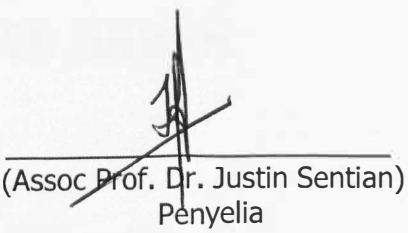

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KONG SOON KAI

FACULTY OF SCIENCE AND NATURAL RESOURCES
UNIVERSITI MALAYSIA SABAH
2016

CLIMATE CHANGE IMPACTS ON SURFACE OZONE IN MALAYSIA REGION

KONG SOON KAI

THESIS SUBMITTED IN FULLFILLMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF SCIENCE AND NATURAL RESOURCES
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2016

DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

14 July 2016

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CERTIFICATION

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DEGREE	:	**DOCTOR OF PHILOSOPHY**
VIVA DATE	:	**19 SEPTEMBER 2016**

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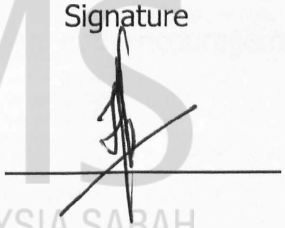

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ABSTRACT

Climate change is a significant change of weather pattern over long period of time. The issue is critical for the region which the economics relying on agriculture and natural resources including Malaysia country. The changing climate in the future period triggered by the future emission scenario could influence the ozone concentration, and eventually causing the health problem more pronounce. The present study examine the impact of regional climate change towards the future air quality over the Malaysia region under Representative Concentration Pathway (RCP) scenarios including RCP8.5 and RCP4.5. The primary investigation is focus on the model performance and how the future climate condition can affect the ozone mixing ratio besides the influence of the related oxidants and precursors. A coupled Weather Research Forecast - Community Multiscale Air Quality (WRF-CMAQ) modeling system has been applied by using the meteorological data from Community Earth System Model (CESM) and Model Inter-Comparison Study for Asia (MISC-Asia) emission inventory as main input to the model. Three sets of simulation were performed for each climate scenarios: one was the baseline period (2010) and another two were the future-day period (2050 and 2100), during the winter and summer monsoons. Generally, the simulation of RCP scenarios downscaled by Weather Research Forecast (WRF) modeling system agrees well with Climate Research Unit (CRU) observation and National Centers for Environmental Prediction (NCEP) reanalysis datasets in simulating the surface temperature by producing a good value of statistical analysis. However, the precipitation did not perform well. The future projection under RCP8.5 and RCP4.5 scenarios revealed that the surface temperature increased across Malaysia region in 2050 and 2100, which may associated with the impact of long-live greenhouse gases (GHG) emission. The patterns of total precipitation were varied for both RCP4.5 and RCP8.5 scenarios. The temperature increased under both scenarios lead to the increased of evaporation and thus causing the more precipitation on land area during that specific period. The study also identified the model deficiencies and evaluated the performance of coupled WRF-CMAQ modeling system in simulating air quality in Malaysia region. The simulation of RCP simulations reproduced well the observed dataset from Department of Environment (DOE) and NCEP reanalysis dataset for maximum 1-hour average surface ozone mixing ratio by producing a good value of statistical analysis. In comparison with present scenario, there was a small decrease of the maximum 1-hour average surface ozone mixing ratio under RCP8.5 scenario, but large decrease for RCP4.5 scenario except the winter monsoon. Generally, the decreased of ozone mixing ratio was found to be affected by climate change as well as to the changes of ozone's oxidants such as hydroxyl radical (OH), nitrogen oxides (NO_x) and acid

nitric (HNO_3). However, the future ozone mixing ratio under both RCP scenarios did not exceed the average 1 hour ozone concentration of the Malaysian Ambient Air Quality Guideline (MAAQG). Therefore, further tightening control measures on the present GHGs emission to reduce future surface ozone seems to be not necessary. However, continuous monitoring is vital to ensure efficient air quality management in Malaysia, and at the same time assessing any possibility of high ozone episodes that causes by other processes such as stratospheric ozone intrusion.

ABSTRAK

KESAN PERUBAHAN IKLIM KE ATAS OZON PERMUKAAN DI RANTAU MALAYSIA

Perubahan iklim adalah perubahan yang ketara bagi corak cuaca dalam tempoh masa yang lama. Isu tersebut adalah kritikal bagi rantau di mana ekonominya bergantung kepada pertanian dan sumber asli termasuk negara Malaysia. Perubahan iklim dalam tempoh masa depan yang dicetuskan oleh senario pelepasan masa depan boleh mempengaruhi kepekatan ozon, dan akhirnya menyebabkan masalah kesihatan yang lebih menonjol. Kajian ini mengkaji kesan perubahan iklim serantau terhadap kualiti udara masa depan di Malaysia di bawah scenario RCP termasuk RCP8.5 dan RCP4.5. Siasatan utama adalah memberi tumpuan kepada prestasi model dan bagaimanakah keadaan iklim pada masa depan boleh menjejaskan nisbah campuran ozon selain pengaruh oksidan dan prekursor yang berkaitan. WRF-CMAQ sistem pemodelan telah diaplikasikan dengan menggunakan data meteorologi daripada CESM dan MISC-Asia inventori pelepasan sebagai input utama kepada model. Tiga set simulasi telah dihasilkan untuk setiap senario iklim: salah satunya adalah tempoh asas (2010) dan dua lagi adalah tempoh masa depan (2050 dan 2100), bagi musim sejuk dan musim panas. Secara amnya, simulasi senario RCP yang dikecilkan skala oleh WRF sistem pemodelan bersetuju baik dengan CRU pemerhatian dan NCEP dataset reanalysis dalam mensimulasikan suhu permukaan dengan menghasilkan nilai yang baik statistik analisis. Walau bagaimanapun, hujan tidak menunjukkan prestasi yang baik. Unjuran masa depan di bawah RCP8.5 dan RCP4.5 senario mendedahkan bahawa suhu permukaan meningkat di seluruh rantau Malaysia pada tahun 2050 dan tahun 2100. Kejadian ini boleh dikaitkan dengan kesan GHG yang lamanya wujud. Corak jumlah hujan menunjukkan perubahan besar untuk kedua-dua RCP4.5 dan RCP8.5 senario. Suhu meningkat di bawah kedua-dua senario membawa kepada peningkatan penyejatan, dan seterusnya menyebabkan hujan lebihan di kawasan tanah dalam tempoh yang tertentu. Kajian ini juga bertujuan mengenalpasti kekurangan model dan menilai prestasi sistem pemodelan WRF-CMAQ dalam mensimulasi kualiti udara di rantau Malaysia. Simulasi RCP diterbitkan semula dengan baik dengan set data permerhatian daripada DOE dan NCEP reanalysis dataset untuk maksimum purata 1 jam bagi nisbah campuran ozon permukaan dengan menghasilkan nilai analisis statistik yang baik. Berbanding dengan senario pada masa kini, terdapat penurunan yang kecil bagi maksimum purata 1 jam bagi nisbah campuran ozon permukaan di bawah senario RCP8.5, tetapi penurunan yang besar untuk senario RCP4.5 kecuali musim sejuk. Secara umumnya, penurunan ozon didapati terjejas oleh perubahan iklim dan juga perubahan oksidan ozon seperti OH, NO_x dan HNO_3. Walau bagaimanapun, ozon pada masa depan di

bawah kedua-dua senario RCP tidak melebihi purata 1 jam kepekatan ozon yang ditentukan oleh Kualiti Garis Panduan Udara Persekitaran Malaysia (MAAQG). Oleh itu, lebihan pengetakan dalam langkah kawalan ke atas GHG pelepasan untuk mengurangkan ozon permukaan masa depan seolah-olah tidak diperlukan. Walau bagaimanapun, pemantauan berterusan adalah penting untuk memastikan pengurusan kualiti udara yang cekap di Malaysia, dan pada masa yang sama menilai sebarang kemungkinan episod ozon yang tinggi yang diyebabkan oleh proses lain seperti pencerobohan ozon stratosfera.

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