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SPATIOTEMPORAL VARIATION ANALYSIS OF ATMOSPHERIC CARBON DIOXIDE CONCENTRATION USING REMOTE SENSING TECHNOLOGY

P. Meena   T. Laosuwan *

Department of Physics, Faculty of Science, Mahasarakham University, Kantarawichai District, Maha Sarakham, Thailand, pattanapol.m@msu.ac.th, teerawong@msu.ac.th
**. Corresponding Author*

Abstract- Greenhouse gases (GHGs) play an essential role in maintaining a constant temperature in the earth's atmosphere, but their excessive amounts lead to climate change. Carbon dioxide (CO_2), in particular, contains the largest amount of 70% of all GHGs and remains in the atmosphere longer than other GHGs. The primary objective of this study was to analyze spatiotemporal changes in time variation and factors influencing CO_2 concentration in Thailand's atmosphere using Greenhouse Gases Observing Satellite (GOSAT) data over a period of 5 years starting from 2015 to 2019. The operation uses data from GOSAT satellites for analysis spatiotemporal variation and influencing factors on CO_2 concentration with Map Algebra Technique and Interpolation Technique. The results can be described as follows: (1) CO_2 concentrations based on spatiotemporal variation were found to have the lowest value in February 2015 of 394,454 ppm and continued to increase, with the highest at December 2019 of 412,378 ppm, (2) CO_2 concentra-tions from sea level altitude factors were found to have the lowest value in 2015 which was 397,459 ppm and the highest value in 2019 was 407,129 ppm, and (3) CO_2 concentrations from seasonal factors including temperature and precipitation, which was found to fluctuate with seasonality of CO_2. During winter and summer, the level of the CO_2 concentrations in the atmosphere varied with temperature. During the rainy season, the CO_2 in the atmosphere decreases due to the high growth rate of vegetation, resulting in CO_2 being sequestration from the atmosphere for use in photosynthesis.

Keywords: CO_2, Spatiotemporal Variation, Remote Sensing, Influencing Factors.

1. INTRODUCTION

Greenhouse gases, or GHGs for short, is a gas that has the ability to absorb heat radiation or infrared radiation [1]. These gases are essential to maintaining a constant temperature in the Earth's atmosphere [2]. Which, if the Earth's atmosphere does not have GHGs in the atmosphere like other planets in the solar system, it will cause the temperature to be extremely hot in the day and extremely cold in the night [3]. GHGs are not a type of gas, but rather a group of gases that can collect and absorb solar radiation gradually during the day [4].

Radiant heat is emitted at night, causing the global atmosphere temperature to not change suddenly. These gases comprise of carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFC), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) [5-7]. Scientists focus on the first three gases (CO_2, CH_4, N_2O) the most, especially CO_2, which accounts for more than 70% of the GHGs content [8-10]. And although it absorbs less thermal radiation than CH_4 and N_2O, due to its greater release and longer existence in the atmosphere, CO_2 has a greater role in climate change. The World Meteorological Organization (WMO) studies clearly showed that the most important and substantial GHGs in the atmosphere was CO_2, which increased dramatically from 280 ppm during the year 1800, increased to 360 ppm in the year 2000 and that it skyrocketed to 407 ppm in 2017 [11]. When the amount of CO_2 is increased in the atmosphere [12,13]. This causes the global temperature to rise to the greenhouse effect and bring about global warming and climate change [14].

For the atmospheric GHGs assessment method, it can be directly or indirectly assessed using the GHGs analysis technique. The direct atmospheric GHGs analysis can be performed by direct sampling. GHGs values can be obtained directly from the atmosphere [15]. This is a difficult analysis because GHGs is constantly circulating due to influencing factors such as the area's sea level altitude, seasonal factors including temperature and rainfall, etc. Indirect GHGs analysis can be performed by inverse modeling, depend on an improved understanding of the carbon exchange processes in the atmosphere and on the ground (process-based surface modeling) and field data analysis to study the process of carbon exchange between the atmosphere and the ground (inventory-based calculation), each of which has limitations on space and time [16-18].

Currently, remote sensing technology, by using data from satellites, has developed a sensor device capable of analyzing the values of reflection and absorption of waves in the reflection infrared and thermal infrared regions (thermal Infrared) can be directly differentiated from GHGs particles in the atmosphere [19-21]. It is high spatial coverage and high temporal, which is useful for assessing the tracking, distribution and variation of GHGs in the atmosphere. Because of the reasons and importance of the change in the amount of GHGs in the atmosphere, especially the rapidly increasing CO_2 content [22-25]. This study therefore had an objective to analyze spatiotemporal variation and influencing factors on atmospheric CO_2 concentration in Thailand using GOSAT data over a period of 5 years starting from 2015 to 2019.

2. MATERIAL AND METHOD

2.1. Data Collection

The Greenhouse Gases Observing Satellite (GOSAT or IBUKI) is a Japan Aerospace Exploration Agency mission in Japan's GCOM (Global Change Observation Mission) project. It covers an area around the world with a spatial resolution of 10.5 km. The GOSAT is able to analyze the reflectance and radiation values of the infrared spectrum, heat from the earth's exterior and atmosphere, along with the absorption of such radiation by GHGs particles such as CO_2 and CH_4, where the GOSAT is positioned at altitude of 666 km from the Earth. It takes 1 hour and 40 minutes to orbit the Earth, and it returns to its original location every 3 days.

The GOSAT has a transceiver called TANSO, comprised of two devices consist of (1) The Thermal and Near Infrared Sensor for Carbon Observation Fourier-Transform Spectrometer (TANSO-FTS), including Short Wave Infrared (SWIR) 4 bands, and Thermal Infrared (TIR) 1 band and (2) The Thermal and Near Infrared Sensor for Carbon Observation - Cloud and Aerosol Imager (TANSO-CAI) [26]. For this study, GOSAT data between 2015-2019 was selected by selecting the L3 global CO_2 distribution (SWIR) data set.

2.2. Data Analysis

For analysis spatiotemporal variation and influencing factors on atmospheric CO_2 concentration in Thailand (Figure 1) with data from GOSAT satellites using Map Algebra Technique and Interpolation Technique over a period of 5 years, can or described as follow:

(1) Conduct CO_2 analyzes concentrations from 2015 to 2019
(2) Analyze the CO_2 concentration from the factors of elevation above sea level
(3) The CO_2 concentration was analyzed based on seasonal factors including temperature and rainfall.

Analysis results obtained in this study were displayed in mapping and graphs to indicate spatiotemporal variation of CO_2 in Thailand's atmosphere in the form of ppm units. The unit to measure the concentration of CO_2 in atmosphere was expressed as mole fraction, that is, the ratio of the number of moles to the fraction, composed of a given volume per total mole number of elements reported in dry air format.

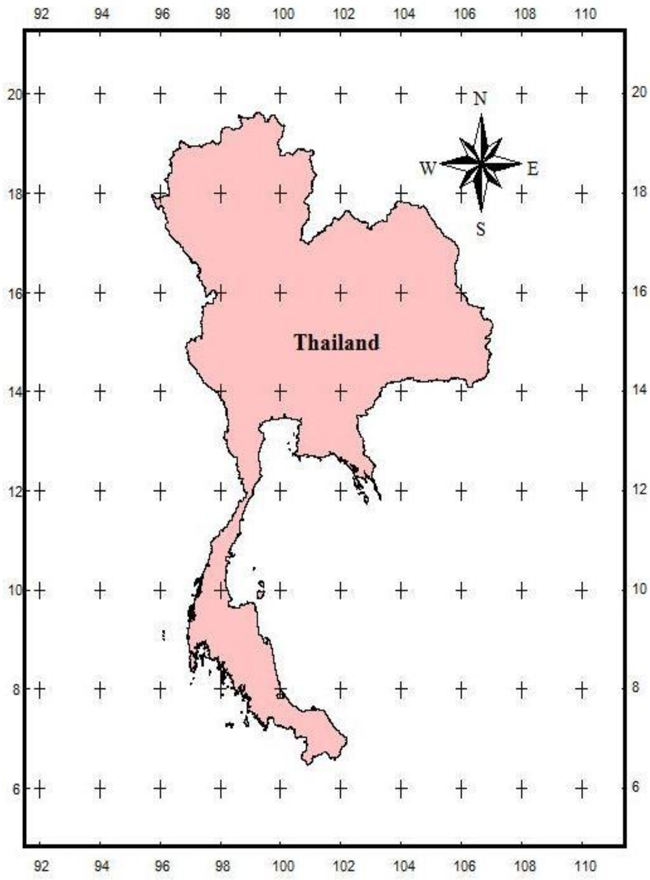


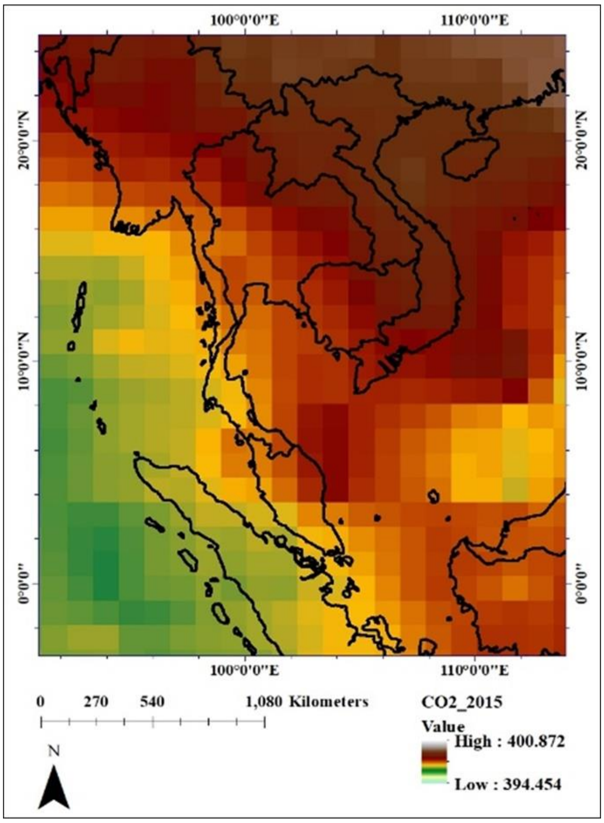
Figure 1. The study area

3. RESULT AND DISCUSSION

3.1. The Results of the Analysis of the CO_2

The results of the analysis of the CO_2 concentration from the analysis of the concentration of atmospheric CO_2 of Thailand with data from GOSAT satellites between 2015 and 2019 using Map Algebra Technique and Interpolation Technique can be shown in Figure 2. From Figure 2, it was found that the CO_2 concentrations in the atmosphere of Thailand was the lowest at 394,454 ppm and the highest at 400.172 ppm. In the year 2016, it was found that the CO_2 concentrations in the atmosphere of Thailand was the lowest at 396.553 ppm and the highest at 405,907 ppm.

In the year 2017, it was found that the CO_2 concentrations in the atmosphere of Thailand was the lowest at 399.155 ppm and the highest at 408.473 ppm. In the year 2018, it was found that the CO_2 concentrations in the atmosphere of Thailand was the lowest at 401,954 ppm and the highest at 410.079 ppm. In the year 2019, it was found that the CO_2 concentrations in the atmosphere of Thailand was the lowest at 404.357 ppm and the highest at 412.378 ppm. In addition, it was found that the CO_2 concentrations in the atmosphere of Thailand fluctuates in a period of 1 year according to the Thailand's seasons.


100°0'0"E
110°0'0"E
20°0'0"N
10°0'0"N
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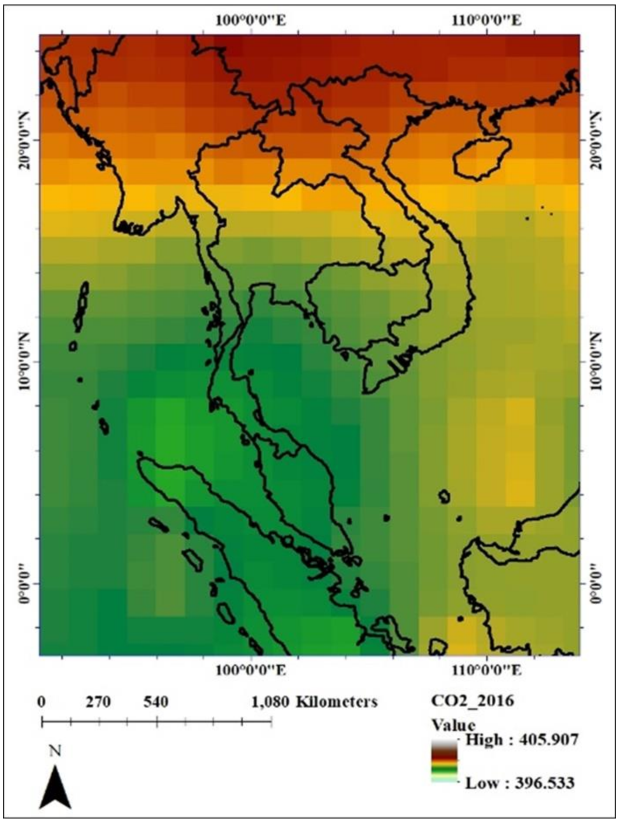
0 270 540 1,080 Kilometers
N
CO2_2015
Value
High : 400.872
Low : 394.454

(a)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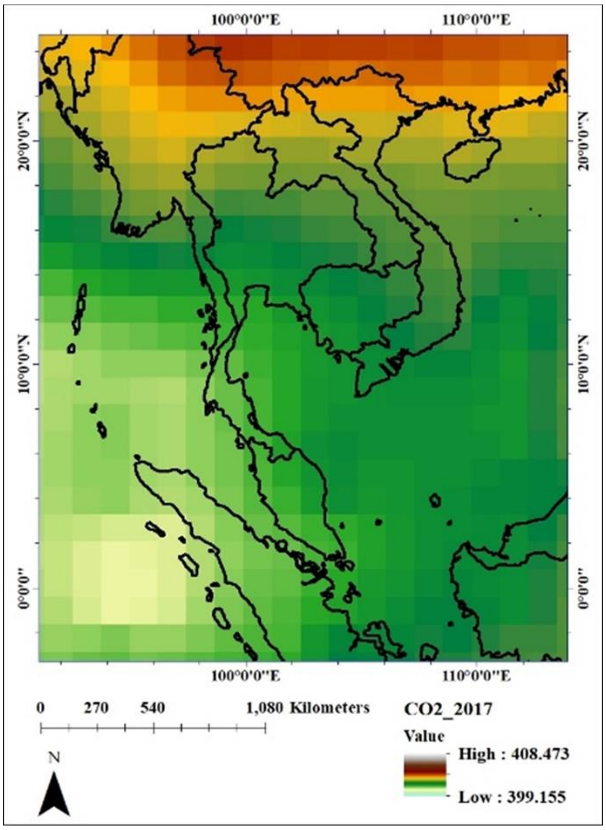
CO2_2016
Value
High : 405.907
Low : 396.533

(b)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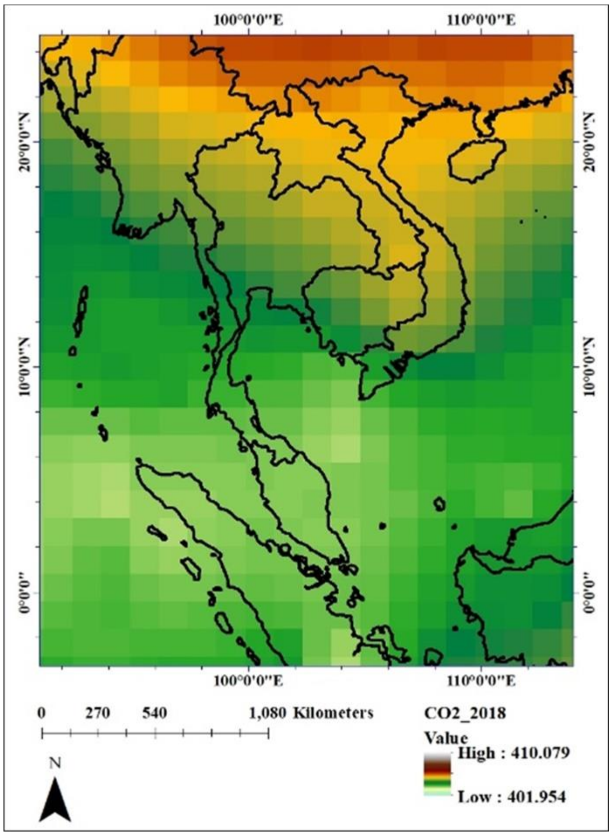
N
CO2_2017
Value
High : 408.473
Low : 399.155

(c)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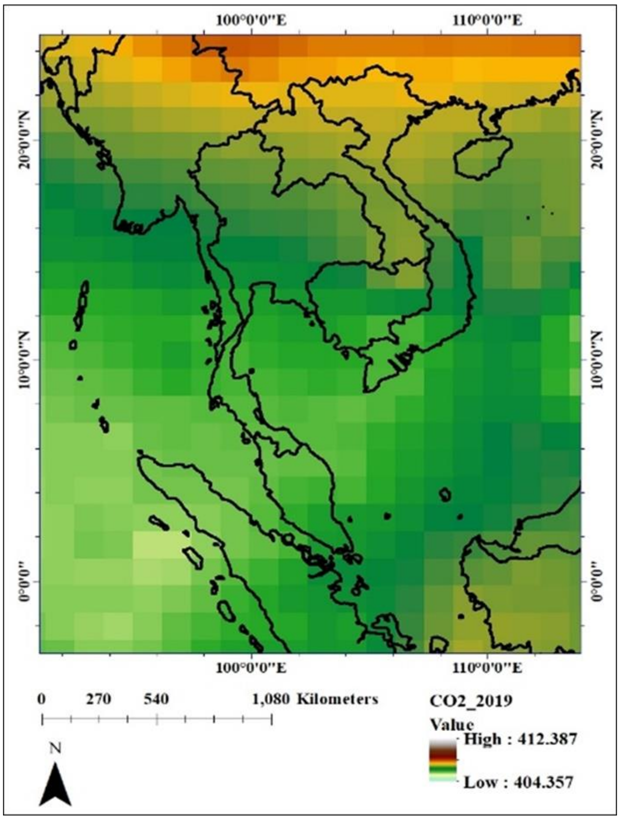
0 270 540 1,080 Kilometers
N
CO2_2018
Value
High : 410.079
Low : 401.954

(d)



(e)

Figure 2. Concentration of atmospheric CO_2 of Thailand, (a) 2015, (b), 2016, (c) 2017, (d) 2018, and (e) 2019

Table 1. Monthly of CO_2 concentration in the atmosphere of Thailand

Month	CO_2 Concentration (ppm)
Jan.	N/A
Feb.	394.454
Mar.	395.209
Apr.	397.341
May	396.334
Jun.	398.969
Jul.	400.172
Aug.	398.474
Sept.	398.419
Oct.	400.872
Nov.	399.539
Dec.	398.006

(a)

Month	CO_2 Concentration (ppm)
Jan.	397.964
Feb.	396.684
Mar.	396.553
Apr.	N/A
May	399.405
Jun.	N/A
Jul.	400.572
Aug.	400.380
Sept.	398.452
Oct.	405.907
Nov.	399.587
Dec.	N/A

(b)

Month	CO_2 Concentration (ppm)
Jan.	399.155
Feb.	400.526
Mar.	402.829
Apr.	401.614
May	402.816
Jun.	403.392
Jul.	402.191
Aug.	408.473
Sept.	402.709
Oct.	403.606
Nov.	402.913
Dec.	403.097

(c)

Month	CO_2 Concentration (ppm)
Jan.	407.241
Feb.	401.954
Mar.	403.845
Apr.	403.845
May	404.105
Jun.	404.504
Jul.	406.739
Aug.	405.615
Sept.	406.796
Oct.	410.079
Nov.	404.366
Dec.	407.241

(d)

Month	CO_2 Concentration (ppm)
Jan.	405.960
Feb.	405.785
Mar.	406.606
Apr.	404.357
May	407.261
Jun.	407.504
Jul.	410.155
Aug.	410.546
Sept.	409.148
Oct.	408.924
Nov.	407.860
Dec.	412.378

(e)

3.2. The Analysis Results of CO_2 Concentration from Elevation from Sea Level

The results of the analysis of the atmospheric CO_2 The results of the analysis of the atmospheric CO_2 concentration of Thailand from the factors of elevation from sea level ranging from 10 m to 975 m can be shown in Figure 3. From Figure 3, it was found that Thailand, at an altitude of 10 meters to 200 meters above sea level, the mean CO_2 concentration increased at a high rate. And the rate of increase tended to decrease at an altitude of 200 meters or more. The highest average CO_2 concentration was at an altitude of about 900 meters, compared with the annual mean CO_2 concentration between 2015 and 2019. In the Thai atmosphere, it was found that the CO_2 concentrations continued to increase. In 2015, the lowest CO_2 concentration was 397.459 ppm, while in 2019, the highest CO_2 concentration was 407.129 ppm.

3.3. The Analysis Results of the CO_2 from Seasonal Factors

The analysis results of the CO_2 concentration from seasonal factors such as temperature and precipitation in this study can be explained that the CO_2 concentration varies with temperature as shown in Figure 4, also. There was also variation in rainfall as shown in Figure 5.

However, during the hot summer months there is an increased amount of fuel consumption which resulted in higher levels of the CO_2 in the atmosphere of Thailand. During the rainy season, atmospheric CO_2 decreases as vegetation increased photosynthesis, where the frozen atmospheric CO_2 was reused in vegetation photosynthesis and converted to carbon to accumulate in the form of wood. During the winter, there were many adaptations of plants, with complex mechanisms involved with a large number of enzymes, as well as chemical processes to destroy the green chlorophyll until the vegetation had deciduous. As a result, the retained atmospheric CO_2 in the plant's photosynthesis was reduced and air humidity was low, reducing the conversion of CO_2 to carbonic acid, resulting in the concentration of CO_2 to increase. Moreover, higher global temperatures also caused the dissolved CO_2 to evaporate in the ocean seawater.

4. CONCLUSIONS

CO_2 is the gas that accumulates the heat energy in the earth's atmosphere and causes the world's temperature to rise the most among other greenhouse gases. Much of the CO_2 is produced by human actions such as combustion of fuels, transportation and industrial production. The primary objective of this study was to analyze spatiotemporal variation and influencing factors of atmospheric CO_2 concentration in Thailand with data from GOSAT satellites over a five-year period from 2015 to 2019.

For this research, it can be concluded that from the 5-year period of study, it was found that the CO_2 concentrations in the atmosphere of Thailand fluctuated in one year according to season. In the year 2015, there was a concentration of average annual that the CO_2 in the atmosphere of Thailand at 398.019 ppm. In the year 2016, there was a concentration of average annual that the CO_2 in the atmosphere of Thailand at 399.289 ppm. In the year 2017, there was a concentration of average annual that the CO_2 in the atmosphere of Thailand at 402.548 ppm. In the year 2018, there was a concentration of average annual that the CO_2 in the atmosphere of Thailand at 405.387 ppm. In the year 2019, there was a concentration of average annual that the CO_2 in the atmosphere of Thailand at 407.807 ppm. In addition, the results of this study are consistent with two similar studies by TGO (2016) [27] and TGO (2018) [28].

The results of this study can be used as baseline in situation monitoring CO_2 in the atmosphere of Thailand. This will enable government agencies and related departments to formulate policies and plan implementation projects that will reduce emissions and increase effective removal of CO_2, as well as providing further information to support the adaptation to the impacts of climate change of the country.

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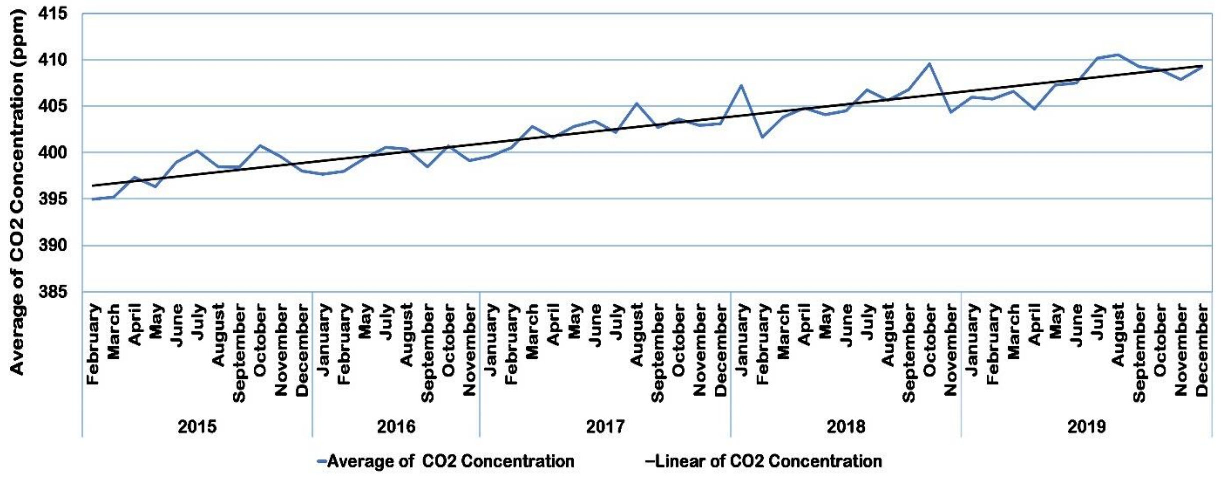

Figure 3. CO_2 concentration from elevation of sea level

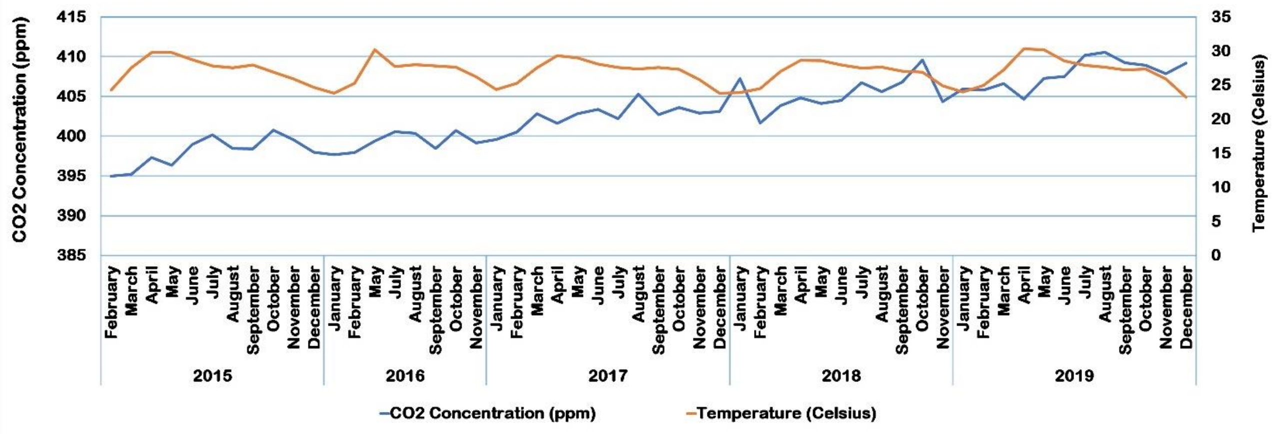

Figure 4. CO_2 concentration from seasonal factors, temperature

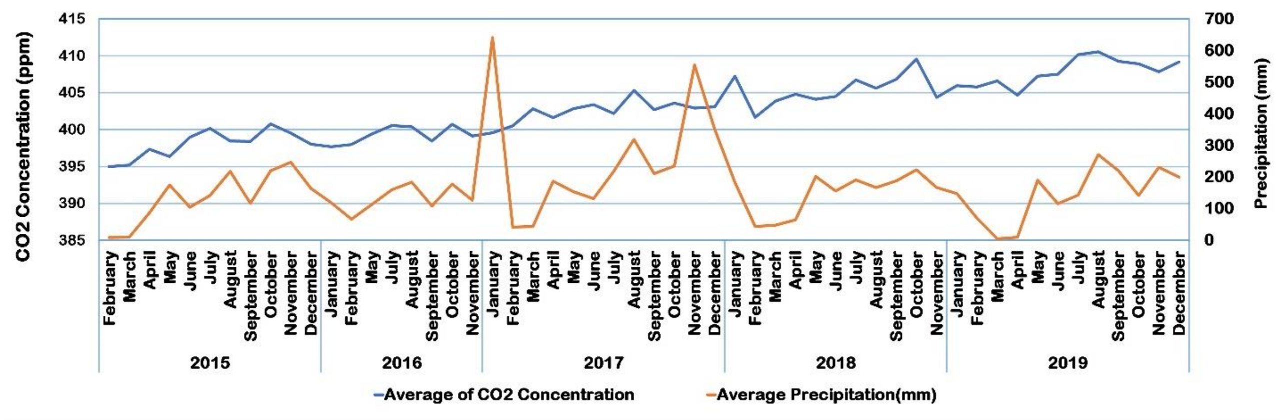

Figure 5. CO_2 concentration from seasonal factors, precipitation

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BIOGRAPHIES

Pattanapol Meena was born in Khonkean, Thailand on May 17, 1972. He received the Ph.D. degree in energy technology from Mahasarakham University, Thailand in 2006. Currently, he is Associate Professor at Department of Physics, Mahasarakham University, Mahasarakham, Thailand. His research interests are in the energy technology, renewable energy, heat pipe, solar collector and drying and remote sensing application, etc.

Teerawong Laosuwan was born in Hat Yai, Songkhla, Thailand on October 2, 1971. He received the Ph.D. degree in electrical and computer engineering from Mahasarakham University, Thailand in 2012. Currently, he is an Associate Professor at the Department of Physics, Mahasarakham University, Mahasarakham, Thailand. His research interests are in the remote sensing, geo-informatics, GIS modeling, mobile application development, drone surveying and mapping, etc.