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Observations of Atmospheric Carbon Monoxide and Formaldehyde in Thailand Using Satellites

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Abstract

Carbon monoxide (CO) and formaldehyde (CH_2O) are air pollutants playing an important role in the formation of tropospheric ozone (O_3), which in turn have an influence on climate change. This study investigated the levels of CO and CH_2O in Thailand during the periods of 2007 to 2017 (11 years). The observed data of CO were collected from the MOPITT satellite. For CH_2O, the observed data were collected from the OMI satellite. Overall, during the study period, CO were detected at high levels from October to April and at low levels from May to September. For CH_2O, the higher levels were detected from February to May while the lower levels were detected from June to September. Moreover, ground monitoring data of CO and CH_2O were also obtained from the Pollution Control Department (PCD) from all over Thailand to compare with the satellite observed data. The results showed well correlated between satellite and ground CO levels in term of monthly pattern. However, the correlation between satellite and ground CH_2O was relatively low. The results in this study showed that satellite observations of CO are useful to support ground measurements, particularly when ground monitoring stations are limited.

***Keywords**:* CO; CH_2O; Satellites; MOPITT; OMI; Thailand

1. Introduction

Nowadays, most of the variation of the weather, which has critical changes, is arise from pollution that emitted to the earth's atmosphere. This study is focusing on two of the air pollution has significantly affect to atmosphere and also the climate change. Carbon Monoxide is colorless, odorless, and tasteless gas that is slightly less dense than air (Logan *et al*, 1981), which the global lifetime of CO is about two months and CO can be used as a tracer for pollution from anthropogenic activities and biomass burning (Brasseur *et al*., 1999; Choi et al., 2006). And Formaldehyde (CH_2O) is formed in atmosphere as a result of the oxidation of volatile organic compounds (VOCs), which causes a number of health problems such as headache, disease, and cancer (Olsen *et al*., 1984; Malaka *et al*.).

Satellites based measurement of troposphere CO is being carried out by

Measurement of Pollution in the Troposphere (MOPITT) (Drummond, 1989; Deeter *et al.*, 2003; Deeter, 2013). For CH_2O estimated changes in the chemical sensitivity of ozone production, using Ozone Monitoring Instrument (OMI) (Marais *et al.*, 2013; Barkley *et al.*, 2013; Maris *et al.*, 2014).

In this study, the data on CO and CH_2O from the satellites in Northern and Central of Thailand was collected between 2007 to 2017 and 2007 to 2016 respectively, and then compared with ground data of CO, CH_2O, and relative humidity (RH)

2. Materials and Methods

2.1 Satellites data

CO data were retrieved from MOPITT level 3 data in HDF format from Terra with over path time at 09.00 in the morning. MOPITT Total CO column (100-900 hPa) with the unit of molecules per square centimeter (mol/cm^2) and MOPITT Surface CO (near earth's surface) with the unit of part per billion by volume (ppbv).

CH_2O data was retrieved from OMI/AURA level 3 data in ASCII format, which the unit is molecules per square centimeter (mol/cm^2).

2.2 Ground monitoring data

Hourly ground monitoring data of CO and CH_2O concentrations in this study were obtained from 44 and 7 stations respectively from PCD in unit of part per billion (ppb) for CO and microgram per cubic meter (µg/m^3) for CH_2O, Thailand where located in the northern region (14 stations of PCD CO and 2 station of PCD CH_2O) and the central region (30 stations of PCD CO and 5 stations of PCD CH_2O) during 2007-2017 (11 years). Three hours averaged (9.00-12.00) data of PCD CO were compared with satellite data. Satellites data falling within the same 1°×1° grid boxes of CO and 0.25°×0.25° grid boxes of CH_2O. The locations of PCD stations were shown in Fig. 1. and Fig. 2.

2.3 Data Analysis

CO data from Terra satellite was estimated and correlated with 3 hourly averages at ground data.

CH_2O data from Aura satellite was estimated and correlated with monthly averages at ground data.

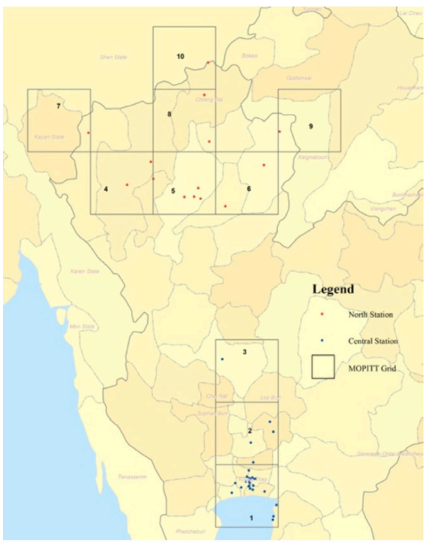

Figure 1. The location of PCD CO stations in northern and central of Thailand.

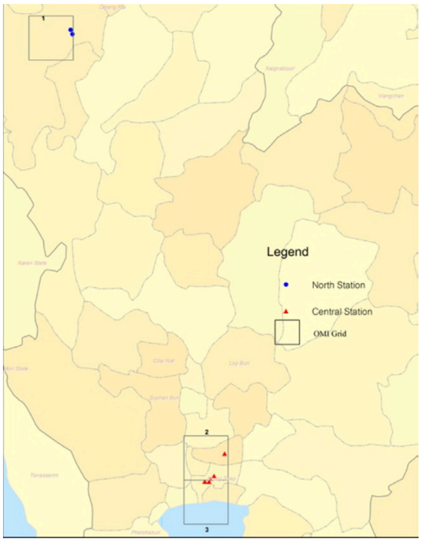

Figure 2. The location of PCD CH_2O stations in northern and central of Thailand.

3. Results and Discussion

3.1 Time series of ground and MOPITT CO

Fig. 3 (a-d) shown the daily plots of PCD CO versus MOPITT Total CO Column and the daily plots of PCD CO versus MOPITT Surface CO for the 11 years period (Jan 2007 to Dec 2017) in northern and central of Thailand Both satellite and ground of CO were detected at high levels from October to April which the highest levels presented in March for north and December to March for central of Thailand. This is due to the occurrence of burning biomass activities in northern during February to April affected higher levels than other months (Lalitaporn P, 2018). And the low levels in northern and central of Thailand were both detected in May to September, which was the wet season in Thailand.

3.2 Correlation of ground and MOPITT CO

Fig. 4.(a-b) shown the scattering plot of PCD CO versus MOPITT Total CO Column in northern and central of Thailand. The results indicate that the correlation (R) of northern was higher than central which 0.68 in northern and 0.54 in central region.

Fig. 5.(a-b) shown the scattering plot of PCD CO versus MOPITT Surface CO in northern and central of Thailand. The results indicated that the correlation (R) of northern was higher than central which R value of northern was 0.72 and 0.61 in central region.

In the MOPITT Surface CO both northern and central regions have the R value better than MOPITT Total CO Column due to the MOPITT Surface CO data are more representative of the ground measured CO levels which in turn reflect the influence of local emission source (Sulitapaneenit M. *et al.*, 2014). The highest levels presented in March for north and December to March for central of Thailand.

3.3 Comparison of RH and MOPITT CO

Fig. 6.(a-b) Scattering plots between RH versus MOPITT Total CO column in northern and central region, Thailand which the R value are -0.42 and -0.08 respectively.

Fig. 7.(a-b) Scattering plots between Relative Humidity versus MOPITT Surface CO in northern and central region, Thailand which the R value are -0.45 and -0.12 respectively.

In the result showed the R value of MOPITT Surface CO has better than MOPITT Total CO column, which matched in satellites and ground CO in previous subtitle, however the trend of linear equations was decreasing trend which is different from satellites versus ground CO that were increasing trend. Due to the CO becomes solidified after absorbing

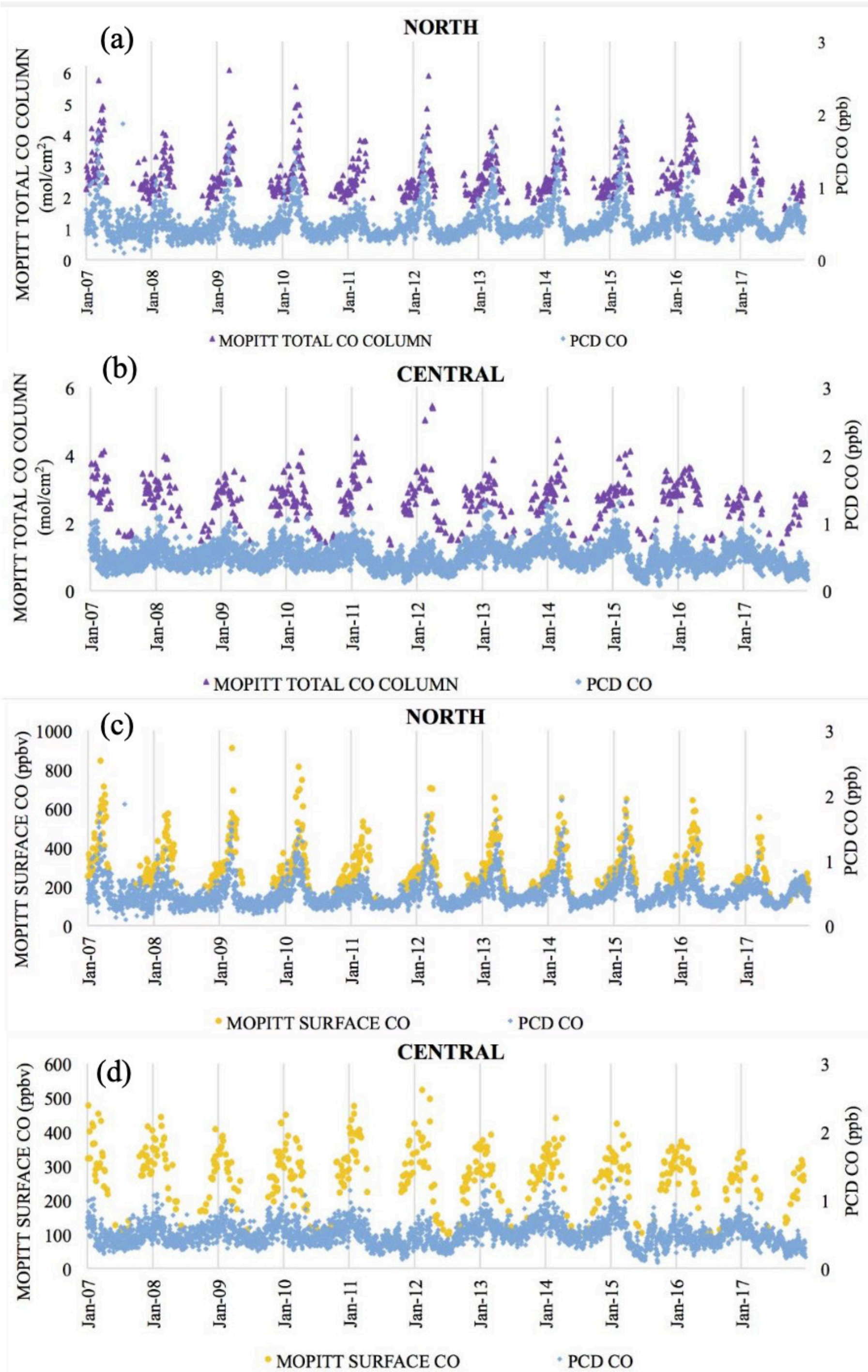

Figure 3. Daily plots of (a) PCD CO versus MOPITT TOTAL CO COLUMN in Northern Thailand (b) PCD CO versus MOPITT TOTAL CO COLUMN in Central Thailand (c) PCD CO versus MOPITT SURFACE CO in Northern Thailand (d) PCD CO versus MOPITT SURFACE CO in Central Thailand.

moisture or getting wet, which is happen in wet season. The RH of northern Thailand is high (53.80) and central Thailand is low (39.74).

3.4 Monthly analysis of OMI CH_2O

Fig. 8. shown monthly time series of OMI CH2O in Northern and Central of Thailand. The high levels occurred during February to May (dry season) while the lower levels occurred during June to September (wet season). Moreover, biomass burning still dominates the CH_2O concentration during February to the end of April. These results similar with the study of Rui L *et al*., 2018. In the results of Fig. 9. (a-b) show monthly plots of CH_2O from OMI and ground data in northern and central. The results show low correlations between satellite and ground-based data. CH_2O were collected once a month while satellite data were collected every day. This probably causes low R values. More ground monitoring data of CH_2O are needed in the future for the comparison.

4. Conclusions

In this study, MOPITT CO, OMI CH_2O, ground-based CO and ground-based CH_2O were compared in northern and central, Thailand during 2007-2017 for CO and 2007-2016 for CH_2O. The results show that the high levels between MOPITT CO and ground-based CO data detected during October to April by the highest levels presented in March for north and December to March for central of Thailand., which the occurrence of burning biomass activities in northern during February to April, and the low levels detected during May to September during wet season.

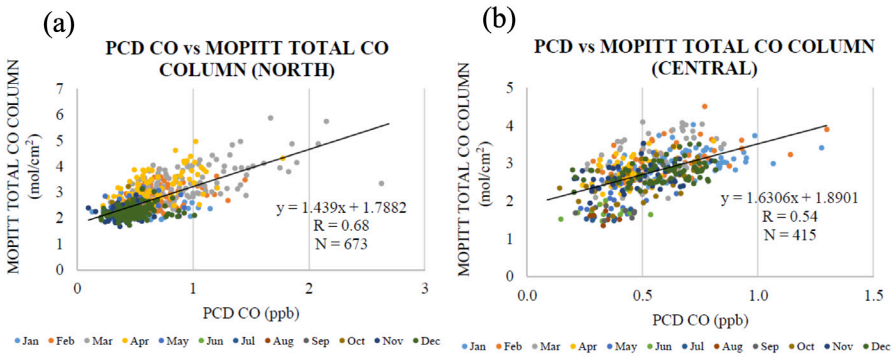

Figure 4. Scattering plots between PCD CO and MOPITT TOTAL CO COLUMN in (a) Northern Thailand and (b) Central Thailand.

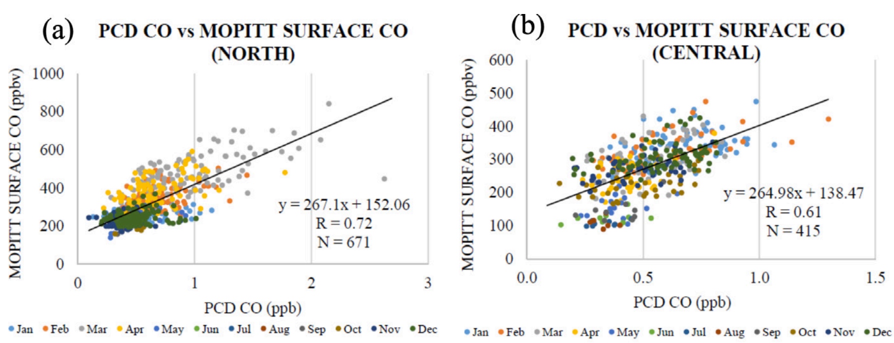

Figure 5. Scattering plots between PCD CO and MOPITT SURFACE CO in (a) Northern Thailand and (b) Central Thailand.

The comparison between MOPITT CO and ground RH show the negative R value due to the difference of relative humidity in each region.

For CH_2O data show the high levels were detected February to May while the lower levels were detected June to September. CO useful to use with ground data. But for CH_2O more ground monitoring data are needed in the future.

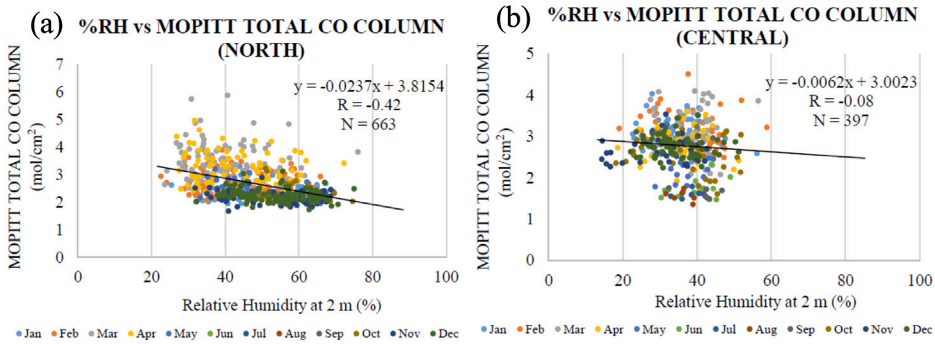

Figure 6. Scattering plots between RH and MOPITT TOTAL CO COLUMN (a) Northern Thailand (b) Central Thailand.

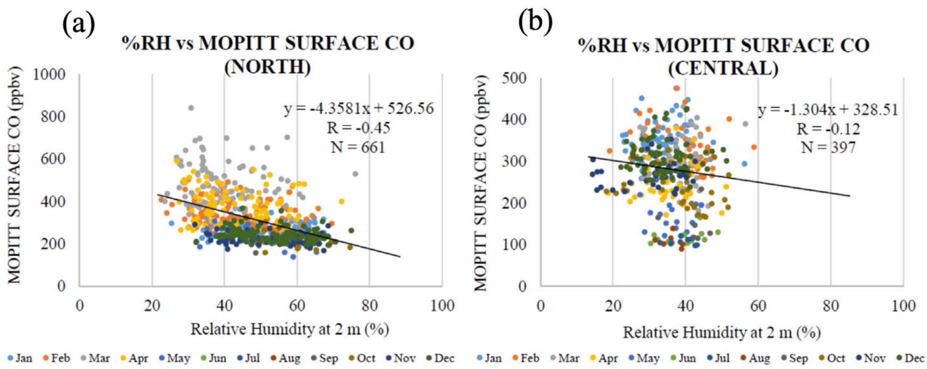

Figure 7. Scattering plots between RH and MOPITT SURFACE CO (a) Northern Thailand (b) Central Thailand.

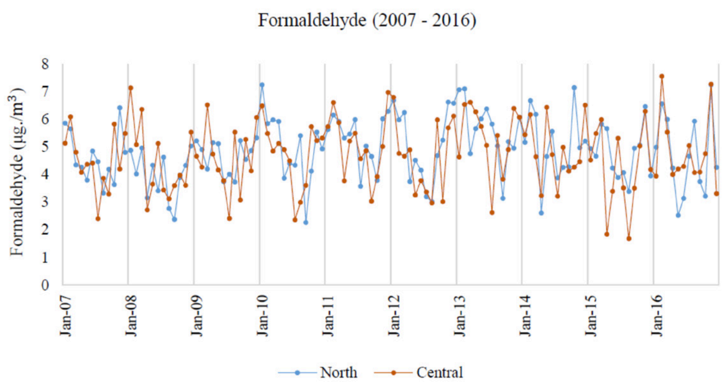

Figure 8. Monthly plots OMI CH_2O in North and Central Thailand.

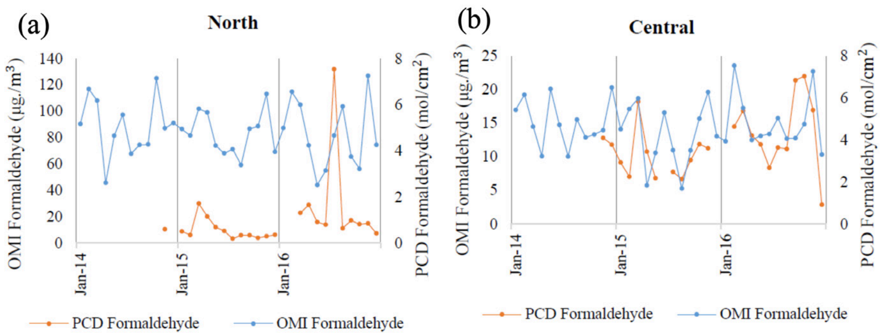

Figure 9. Monthly plots of OMI CH_2O and ground CH_2O in (a) North and (b) Central Thailand.

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