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Characteristics of organic components in $PM_{2.5}$ emitted from peatland fires on Sumatra in 2015: Significance of humic-like substances

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Abstract

We characterize fine particulate matter ($PM_{2.5}$) emitted from Indonesian peatland fires using ground-based source-dominated samplings of $PM_{2.5}$ near peatland fire sources at two Regencies in Riau, Sumatra, Indonesia (number of samples = 13). Organic carbon (OC), elemental carbon, water-soluble OC (WSOC), the carbon content of humic-like substances (HULIS-C), and biomass burning tracers are determined. The carbon mass ratios of WSOC to OC (0.085 ± 0.015) and HULIS-C to WSOC (0.55 ± 0.085) are fairly constant and independent of the peatland fire sampling sites. By comparing diagnostic ratios using OC, WSOC, and HULIS-C at the peatland fire source and the receptor site (Malaysia) during peatland fire-induced haze periods, secondary WSOC and HULIS-C formation during transport from the source to the receptor site is highly possible. Interestingly, the mass ratio of syringic acid to levoglucosan (0.045 ± 0.0075) is fairly constant at Indonesian peatland fire sources. Because syringic acid is less stable than levoglucosan, this ratio is an aging indicator for Indonesian peatland fires at receptor sites. By comparing the mass fraction of each organic compound in the present study and previous studies, it is evident that the source profile for the coburning of peat with surface vegetation is significantly different compared with the burning of peat alone. Further knowledge of peat burning emissions is needed, particularly with respect to burning conditions, peat composition, and the effects of vegetative burning on peatland. Improved knowledge of these factors would lead to more reliable speciated emission inventories of Indonesian peatland fires, advancing chemical transport and radiative forcing modeling, as well as health risk assessment. © 2021

Author keywords

Biomass burning; HULIS; Indonesia; Peatland fire; $PM_{2.5}$; Source profile

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The impact of temporal variability in prior emissions on the optimization of urban anthropogenic emissions of CO_2, CH_4 and CO using in-situ observations

Ingrid Super, Stijn N.C. Dellaert, Janot P. Tokaya, Martijn Schaap
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Characteristics of organic components in $PM_{2.5}$ emitted from peatland fires on Sumatra in 2015: Significance of humic-like substances

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Keywords:
Peatland fire
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ABSTRACT

We characterize fine particulate matter ($PM_{2.5}$) emitted from Indonesian peatland fires using ground-based source-dominated samplings of $PM_{2.5}$ near peatland fire sources at two Regencies in Riau, Sumatra, Indonesia (number of samples = 13). Organic carbon (OC), elemental carbon, water-soluble OC (WSOC), the carbon content of humic-like substances (HULIS-C), and biomass burning tracers are determined. The carbon mass ratios of WSOC to OC (0.085 ± 0.015) and HULIS-C to WSOC (0.55 ± 0.085) are fairly constant and independent of the peatland fire sampling sites. By comparing diagnostic ratios using OC, WSOC, and HULIS-C at the peatland fire source and the receptor site (Malaysia) during peatland fire-induced haze periods, secondary WSOC and HULIS-C formation during transport from the source to the receptor site is highly possible. Interestingly, the mass ratio of syringic acid to levoglucosan (0.045 ± 0.0075) is fairly constant at Indonesian peatland fire sources. Because syringic acid is less stable than levoglucosan, this ratio is an aging indicator for Indonesian peatland fires at receptor sites. By comparing the mass fraction of each organic compound in the present study and previous studies, it is evident that the source profile for the coburning of peat with surface vegetation is significantly different compared with the burning of peat alone. Further knowledge of peat burning emissions is needed, particularly with respect to burning conditions, peat composition, and the effects of vegetative burning on peatland. Improved knowledge of these factors would lead to more reliable speciated emission inventories of Indonesian peatland fires, advancing chemical transport and radiative forcing modeling, as well as health risk assessment.

1. Introduction

Indonesia has the largest area of tropical peatland (2.7×10^5 km^2) in the world that has been drained and cleared of natural vegetation, making said area susceptible to fire (Joosten, 2010; Kiely et al., 2019). Peat stores large quantities of carbon in the form of partially decayed organic matter. Indonesian peatland in particular has a carbon store of ~60 PgC, which is ~65% of the tropical peatland carbon reservoir (Nechita-Banda et al., 2018; Page et al., 2011). Peatland fires on Kalimantan and Sumatra in Indonesia emit considerable amounts of carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), and fine particulate matter ($PM_{2.5}$) (Huijnen et al., 2016; Kiely et al., 2019; Nechita-Banda et al., 2018; Page et al., 2002). The generated smoke is dense and can cause domestic and transboundary haze pollution in Southeast Asia (Balasubramanian et al., 2003; Behera and Balasubramanian, 2014; Betha et al, 2013, 2014; Fujii et al., 2015b, 2016, 2017, 2019; Keywood et al., 2003; Khan et al., 2016; Reddington et al., 2014; See et al., 2006, 2007). The El Niño dry season in 2015 was the strongest Indonesian peatland fire episode since 1997, and the total carbon amount released from September to October in 2015 is estimated to be 227 ± 67 TgC, of which 83% was in the form of CO_2, 16% was in the form of CO, and 1% was in the form of CH_4 (Huijnen et al., 2016). Jayarathne et al. (2018) reported that from the 2015 fire event, the total amount of $PM_{2.5}$ released into the atmosphere is estimated to be 6.0 ± 5.5 Tg, with major contributions from organic carbon (OC; 4.3 TgC). Wiggins et al. (2018) reported that the peat smoke accounted for approximately 85% of smoke plumes reaching Singapore, based on the radiocarbon content of carbonaceous $PM_{2.5}$ samples collected in Singapore from September

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Satellite-based estimates of nitrogen oxide and methane emissions from gas flaring and oil production activities in Sakha Republic, Russia

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Keywords:
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ABSTRACT

Crude oil production activities and associated petroleum gas (APG) flaring are responsible for significant air polluting and greenhouse gas (GHG) emissions and have negative effects on the environment and climate. In Russia, one of the world's major oil producers, APG flaring remains a routine practice despite regulatory policies. We present the first analysis of nitrogen oxide and methane emissions over Tas-Yuryakh and Talakan oil fields in Sakha Republic (Eastern Siberia, Russia) using multi-satellite observations.

Satellite-based TROPOMI (TROPOspheric Monitoring Instrument) nitrogen dioxide (NO_2) mean fields show local NO_2 enhancements corresponding to the locations of gas flares detected from Sentinel 2 imagery and VIIRS (Visible Infrared Imaging Radiometer Suite) fire data. We derive the annual nitrogen oxide ($NO_x = NO_2$+NO) emissions from TROPOMI NO_2 observations using an exponentially-modified Gaussian model. We obtain NO_x emissions up to 1.34 mol/s (in 2019) in Tas-Yuryakh, where persistent production APG flaring is detected, and about 0.6 mol/s in Talakan, where oil production is three times larger than in Tas-Yuryakh but gas flaring is employed only occasionally. In 2019 we observe a new flaring site in Tas-Yuryakh from the NO_2 mean fields, corresponding to an increase in the environmental fees paid by the companies to the local budgets. Assuming that all NO_x emissions are associated with APG flaring, the volume of gas flared for 2019 is estimated at 1.25 ± 0.48 billion cubic metres (bcm) in Tas-Yuryakh and 0.5 ± 0.2 bcm in Talakan.

Furthermore, we find a clear methane (CH_4) anomaly of about 30 ppb from the TROPOMI XCH_4 mean fields near Talakan oil field. We estimate CH_4 emissions of about 28–63 tons/h from individual TROPOMI XCH_4 plumes using the cross-sectional flux method.

The estimated satellite-based NO_x and CH_4 emissions are higher than the inventories, which are expected to underestimate the contribution from the oil and gas industry and are generally available with several years of delay. TROPOMI NO_2 and CH_4 observations demonstrate their capability in identifying emission sources from space with unprecedented detail. The results show how satellite observations can support environmental authorities in monitoring the emissions from the oil and gas industry and the commitment of oil companies in reducing APG flaring.

1. Introduction

Associated petroleum gas (APG) flaring is a diffuse practice in the oil industry that can have significant effects on the environment and climate, due to the associated air polluting and greenhouse gas (GHG) emissions. As the oil is extracted, the APG, present in solution with the crude oil, is released. Part of this gas can be captured during the extraction process to be used as fuel, but often it is released to flare during the oil extraction, production or processing phases. Gas flaring from oil extraction emits several air pollutants, including nitrogen oxides ($NO_x = NO + NO_2$) and methane (CH_4) among other components. Methane is also emitted through leakages or venting during oil production.

Nitrogen dioxide (NO_2) is a short-lived gas (lifetime of a few hours)

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Emission estimates and inventories of non-methane volatile organic compounds from anthropogenic burning sources in India

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ABSTRACT

Comprehensive, spatially disaggregated emission inventories are required for many developing regions to evaluate the relative impacts of different sources and to develop mitigation strategies which can lead to effective emission controls. This study developed a 1 km^2 non-methane volatile organic compound (NMVOC) emission model for the combustion of fuel wood, cow dung cake, municipal solid waste (MSW), charcoal, coal and liquefied petroleum gas (LPG) in India from 1993 to 2016. Inputs were selected from a range of detailed fuel consumption surveys and recent emission factors measured during comprehensive studies of local burning sources. For the census year of 2011, we estimated around 13 (5–47) Tg of NMVOCs were emitted from biomass and MSW combustion in India. Around 54% of these emissions were from residential solid biofuel combustion, 23% from open burning of MSW, 23% from crop residue burning on fields and <1% from LPG for cooking. NMVOC emissions from residential combustion were shown to be highly sensitive to the amount of cow dung cake combusted and this acted as a key pollution source across the Indo-Gangetic Plain. The results of this study indicate that multiple mitigation strategies are required across several different categories of burning source to achieve effective NMVOC emission reduction.

1. Introduction

Biomass burning is the second largest global source of trace gases to the troposphere after biogenic emissions (Yokelson et al., 2008; Andreae, 2019). Major sources include wildfires, agricultural crop residue burning on fields and residential solid fuel combustion. Trace gases are released in varying amounts dependent on the combustion conditions and the material burned (Yokelson et al., 1996). Emission factors have been shown to vary significantly for different energy sources such as fuel wood, straw, grass, peat, and cow dung cake (Andreae, 2019). NMVOCs have the potential to significantly reduce local, regional and global air quality though the formation of tropospheric ozone (Pfister et al., 2008; Jaffe and Wigder, 2012) and secondary organic aerosol (SOA) (Alvarado et al., 2015; Kroll and Seinfeld, 2008).

Emissions from domestic biofuel combustion pose significant health risks as approximately 3 billion people cook with solid fuels globally

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The impact of temporal variability in prior emissions on the optimization of urban anthropogenic emissions of CO_2, CH_4 and CO using in-situ observations

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ABSTRACT

Constraining urban emissions is gaining more attention because of the important role of cities in reaching national climate mitigation targets. Urban inverse modelling studies could constrain emissions of large hotspots, but still face many challenges. It has been argued that more detailed information is needed on both atmospheric transport and prior emissions when moving to a higher spatial and temporal resolution. In this work we focus on the description of temporal variability in the prior emissions and examine how it impacts the optimization of urban emissions of CO_2, CH_4 and CO on a monthly time scale representative for a measurement campaign. Currently, temporal profiles based on long-term average activity data are often applied. However, these average temporal profiles are unable to capture a realistic variability in the emissions, such as those imposed by environmental conditions. Therefore, we created a set of location- and time-specific temporal profiles and compared the optimized emissions using these average and specific temporal profiles. We find that using the specific temporal profiles increases the optimized CO_2 emissions with 19%, even though the prior monthly emissions are the same. This suggests a change in the source-receptor relationship that affects comparison of the observed and simulated mixing ratios, leading to a different emission estimate. The impact is also large (~40%) for CH_4, but this is mainly due to the increase in prior emissions caused by redistributing agricultural emissions over all months of the year. Moreover, we show that extrapolating monthly emission estimates to annual estimates, required for reporting, using the various sets of temporal profiles can result in differences of max. 26% for CO_2, 101% for CH_4, and 13% for CO. Therefore, we conclude that an accurate representation of the temporal variability is essential for urban inverse modelling studies.

1. Introduction

The 2015 Paris Agreement describes a climate action plan to mitigate greenhouse gas (GHG) emissions globally (UNFCCC, 2015). The agreement specifies nationally determined emission reduction targets and obliges participating countries to monitor their progress towards achieving their targets. Currently, this reporting is performed annually based on national energy statistics (UNFCCC, 2020). Although this approach is reliable for carbon dioxide (CO_2), national emission estimates for methane (CH_4) and nitrous oxide (N_2O) are associated with relatively large uncertainties (Ganesan et al., 2015). Moreover, emission reporting is done with a lag of two years. Hence, there is a strong call for independent verification of the emissions (reductions) up to present year. For this purpose, inverse modelling frameworks have been developed to estimate emissions (trends) by combining monitoring network data and atmospheric transport models (Bergamaschi et al., 2018; Ciais et al., 2010). First experiences show that inversions can suggest improvements to national emission inventories, as illustrated by Ganesan et al. (2015) for the UK and Ireland.

Urban areas and associated industrial clusters are emission hotspots and responsible for about 70% of the global fossil fuel CO_2 emissions (IEA, 2008). Therefore, an important role is laid out for urban areas in reaching national (and global) climate mitigation targets as laid down in the Paris Agreement. Moreover, many large cities (e.g. C40 cities) have set their own ambitious climate goals. As urban areas often encompass a wide variety of human activities, they are very suitable to monitor the impact of measures in different source sectors and their combined effect. As such, exchange of best practices derived from verified emission

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