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Commentary

Is it time to tackle $PM_{2.5}$ air pollutions in China from biomass-burning emissions?

Yan-Lin Zhang*, Fang Cao

Yale-NUIST Center on Atmospheric Environmental, Nanjing University of information Science and Technology, Nanjing, Jiangsu 210044, China

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ABSTRACT

An increase in haze days has been observed in China over the past two decades due to the rapid industrialization, urbanization and energy consumptions. To address this server issue, Chinese central government has recently released the Action Plan on Prevention and Control of Air Pollution, which mainly focuses on regulation of indusial and transport-related emissions with major energy consumption from fossil fuels. This comprehensive and toughest plan is definitely a major step in the right direction aiming at beautiful and environmental-friendly China; however, based on recent source apportionment results, we suggest that strengthening regulation emissions from biomass-burning sources in both urban and rural areas is needed to meet a rigorous reduction target. Here, household biofuel and open biomass burning are highlighted, as impacts of these emissions can cause local and regional pollution.

1. Introduction

Driven by surging urbanization and industrialization and a rapid growth in the number of motor vehicles and energy consumption, China has frequently experienced large-scale, severe and persistent haze pollution events. For example, extremely high concentrations of $PM_{2.5}$ (particulate matter with an aerodynamic diameter of <2.5 μm) were reported in central and eastern China during Feb 2014 affecting 1.43 million km^2 and ~900 million people. Atmospheric fine particulate matter such as $PM_{2.5}$ is believed to be one of the most important air pollutants in China, leading to a ~1 million/year premature mortality rate (Lelieveld et al.,2013).

On 9th September 2014, the Legislative Affairs Office of China's State Council released the first draft of the highly-anticipated revisions to the Law on Prevention and Control of Atmospheric Pollution, which could presumably improve enforcement of "Atmospheric Pollution Prevention and Control Action Plan" released in September 2013 primarily aiming to reduce inhalable $PM_{2.5}$ by up to 25% by 2017 against 2012 levels. The primary objective of the Action Plan is to regulate $PM_{2.5}$ levels. Specifically, urban $PM_{2.5}$ above the new Chinese $PM_{2.5}$ standard (24 h-mean of 75 $\mu g/m^3$) should be dropped by at least 10% by 2017 compared to 2012. Tighter targets are applied to major industrialized provinces or key urban agglomeration areas such as the Beijing-Tianjin-Hebei (BTH) Province, the Yangtze River Delta (YRD) and the Pearl River Delta (PRD). For examples, $PM_{2.5}$ in the BTH, the YRD and the PRD will be cut by 25%, 20% and 15% respectively and $PM_{2.5}$ in Beijing will be therefore targeted at 60 $\mu g/m^3$. It indicates still a large gap between the targeted goals and guideline (24 h-mean of 35 $\mu g/m^3$) suggested by the World Health Organization. To achieve the above objectives, the Action Plan defines "ten measures" by mainly focusing on regulation of industrial and transport-related emissions with a major energy consumption of fossil fuel such as coal and petroleum. The China's comprehensive and toughest plan is definitely a major step in the right direction and also a milestone in Chinese environmental legislation, signaling a rigorous national effort to improve air quality and public health. However, this is not enough. We argue that strengthening regulation emissions from biomass burning emissions in both urban and rural areas is also needed to meet a rigorous reduction target.

1.1. Importance of biomass-burning emissions

Biomass-burning emissions can produce various air pollutants such as SO_2, NO_x, O_3, CO, volatile organic compounds (VOCs) and tiny particles (i.e. $PM_{2.5}$). A recent study reveals that in addition to primary emissions from coal burning, traffic-related exhaust and biomass burning, secondary PM (i.e. secondary organic matter and secondary inorganic matter) is an important if not a dominant contributor in 4 Chinese megacities of Beijing, Xi'an, Shanghai and

* Corresponding author.
E-mail address: dryanlinzhang@gmail.com (Y.-L. Zhang).

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Guangzhou during winter 2013 (Huang et al., 2014; Zhang et al., 2015). Non-fossil sources contribute on average to 60% of secondary organic matter or ~50% of total carbonaceous aerosols, an important contributor to the observed effect on mortality due to its toxicity. Biomass burning is very likely a major contributor of non-fossil sources as biogenic emissions are very limited during winter in northern China (e.g. Beijing and Xian) due to very low temperatures although biogenic emissions could still be a minor contributor in southern China (e.g. Guangzhou). The importance of biomass-burning contribution to $PM_{2.5}$ has been also reported in urban sites of the PRD (He et al., 2011) and YRD regions (Cheng et al., 2014), two of the most developed regions of China as well as rural/background sites in east and south China (Liu et al., 2013; Zhang et al., 2014). Moreover, the biomass-burning contribution to total black carbon emissions (i.e. the second-largest human-induced contributor to global warming after carbon dioxide) in China were in the range of 34–45% during 1996–2010 by using a technology-based methodology (Lu et al., 2011).

Here we highlight the two most important biomass-burning sources in China: household biofuel combustion and open agricultural residues burning. As a common practice in Chinese rural areas and even in the surrounding regions of some developed areas such as Guangdong Province and Beijing, the household biofuel (e.g. crop residues, fuel woods, etc.) combustion for heating and cooking (Fig. 1) increases ambient particles burden and elevates particulate matter exposures as these toxic pollutants are primarily emitted in indoor environments (Jiang and Bell, 2008). In contrast to higher particulate matter exposure levels in rural households using biomass as the primary fuel, urban households, which used cleaner fuels (natural gas), had significantly lower indoor particulate levels and personal exposures (Jiang and Bell, 2008).

It should be noted that about half of China's population live in rural areas and most of these people still uses solid fuels including coal and biomass fuel (e.g. wood, charcoal, animal dung and crop waste). The use of such fuels in open fires and relatively low-efficient stoves increases particulate matter exposure in indoor environment, associated with a variety of health outcomes such as acute respiratory infections, chronic obstructive pulmonary disease and lung cancer (Lim et al., 2012). The health risk from fine particulate matter exposure in the indoor environment is more crucial given that most people spend 70%–90% of their time indoors (Ezzati et al., 2004). Health risk is particularly high for women and children due to a longer exposure time. According to a report from the World Health Organization, indoor air pollution cause 425,000 deaths ever year in China and it is the fourth leading factor of mortality (Ezzati et al., 2004).

In addition to household biofuel burning, farmers in China often use the "slash and burn" method to clean agriculture field of left-over plant and return nutrients to the soil. As a result, a large amount of air pollution including $PM_{2.5}$ is emitted in the atmosphere, dramatically decreasing air quality. On 29 Oct 2014, smoke and haze hang over large-scale areas of eastern China which is associated to intensive open biomass burning activities evident by the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite images (Fig. 1). Indeed, open crop residues burning have already been banned in China, but local enforcement of regulation is still very weak. It should be pointed out that the current Action Plan almost exclusively rules out $PM_{2.5}$ regulation in rural areas with a population of 700 million (i.e. 51.7% of total China's population) though a recent study shows the impact of biomass-burning emissions is regional and the transport of air pollutant significantly affects regional $PM_{2.5}$ levels and air quality (Cheng et al., 2014). Based on both ground measurements and model simulations (i.e. the WRF/CMAQ (Weather Research and Forecasting (WRF) and Community Multi-scale Air Quality (CMAQ)), Cheng et al. (2014) suggested that $PM_{2.5}$ could be reduced by 51% for the YRD region if biomass burning is completely forbidden and significant health benefit is therefore expected (Cheng et al., 2014).

2. Conclusions and recommendations

Aside from direct effects on human health, scientists demonstrated that so-called "brown carbon" mainly emitted from wood combustion and open biomass burning is an important warming factor in aerosol radiative forcing, which is not well constrained in most climate models (Saleh et al., 2014). Therefore, we strongly believe it is time to tackle particulate matter pollution from biomass-burning emissions, which could reduce atmospheric aerosol burden and also its climate-warming impacts. The reduction of biomass-burning derived particulate matter could be achieved by (1) using cleaner fuels and stoves for household biofuel combustions; (2) developing indoor $PM_{2.5}$ standards; (3) completely prohibiting open biomass-burning activities; (4) re-considering rural areas into the national and regional air

Fig. 1. Photos showing a typical household stove using crop residues and wood fuel in a village of south China (left, photted by Chang-Sheng Yang) and Moderate Resolution Imaging Spectroradiometer (MODIS) open fires in eastern China (right, obtained from http://www.nasa.gov/content/goddard/smoke-and-haze-over-china).

pollution reduction targets and (5) reinforcing implementation of above-mentioned measures at both central and local levels.

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