Confirmation of Illegal Incineration in Rural Areas using Scanning LIDAR

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INTRODUCTION

Rural areas are relatively marginalized in air pollution research compared to large cities and industrial complexes because of the wide area and small population. However, most elderly residents of rural areas are vulnerable to aerosols, so it is necessary to identify the pollution level and strictly control the emission sources. The primary sources of aerosols in rural areas are secondary aerosols, soil/road dust, biomass-burning aerosols, incineration/fuel combustions, vehicle exhaust, and sea-salt. In particular, bio-combustion and illegal incineration cause incomplete combustion to generate black carbon causing climate change and fine particles adversely affecting human health. Also, burning in rural areas includes agricultural by-products such as plastics, and vinyl, which cause harmful fumes and emit toxic gases.

The Korean government prohibits the burning of waste under the Waste Management Act; nevertheless, it often occurs in rural areas conventionally. It is difficult to supervise because it happens in a short time on a small scale in a wide area. This study tried to identify the agricultural burning and estimate emission flux using the horizontal scanning LIDAR (Light Detection and Range).

METHODOLOGY

Measurement site and Instrument

Measurement site: the Gimje Public Sewage Treatment Plant (35.48 °N, 126.51 °E), Gimje-si, Jeollabuk-do, Korea

Measurement period: 31 Jan to 13 Mar in 2021 (for 24 days depending on the meteorological conditions)

Scanning Light Detection and Range (LIDAR)

- Measurement distance: at a radius of 5 km, resolution of 30 m
- Measurement height: 10 m above the ground
- Azimuthal angles : 0–189°
- Laser wavelength : 532 nm and 1064 nm
- Beam spread : 0.3 mrad

Estimation of Emission Flux

The mass entrainment rate (E_m)

$$E_m = 2\pi b \rho_a u_e$$

b: plume size, ρ_a: ambient density and u_e : entrainment velocity

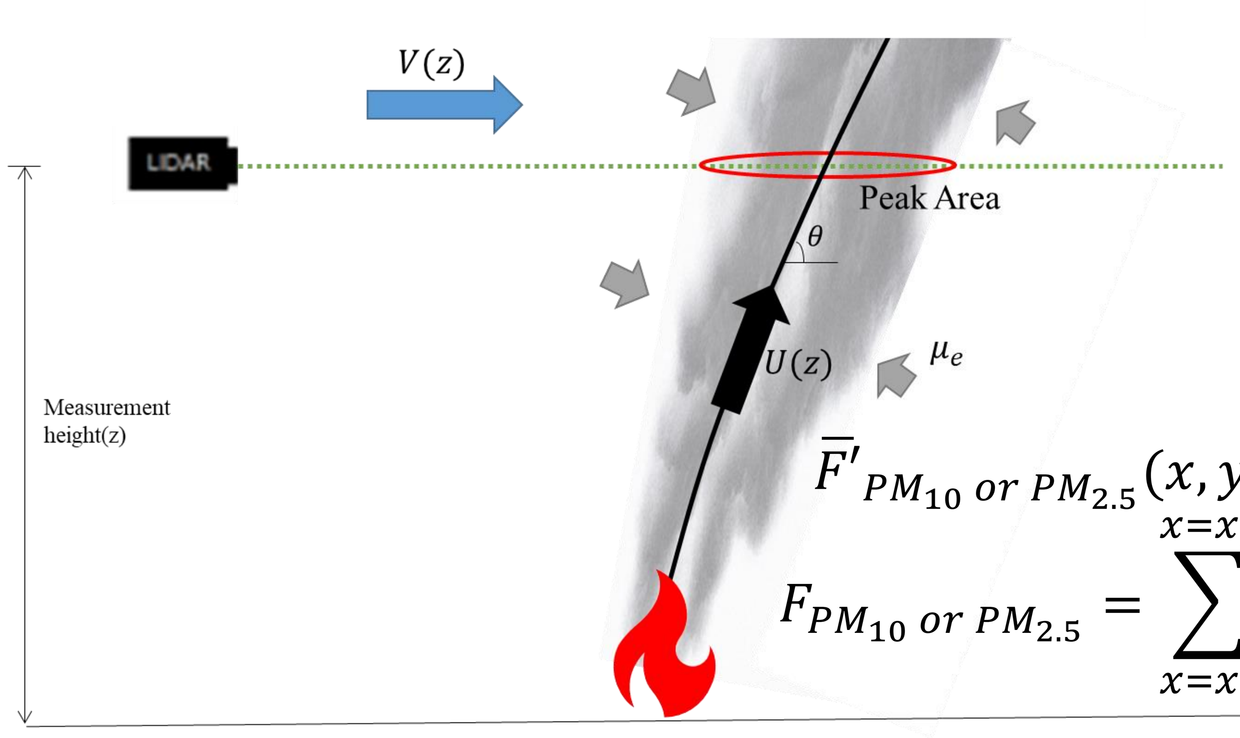
Entrainment velocity can be expressed by wind vectors

$$u_e = k_s|U - V cos\theta| + k_w|V sin\theta|$$

U: the centerline velocity of the plume, V: the horizontal wind, θ: the angle of the plume in the horizontal direction, k_s and k_w: the entrainment coefficients of plume mobility and wind velocity (0.09 and 0.9, respectively)

The centerline velocity is calculated by equation below:

$$|U - V cos\theta| = \frac{E_m/2\pi b \rho_a - k_w|V sin\theta|}{k_s}$$

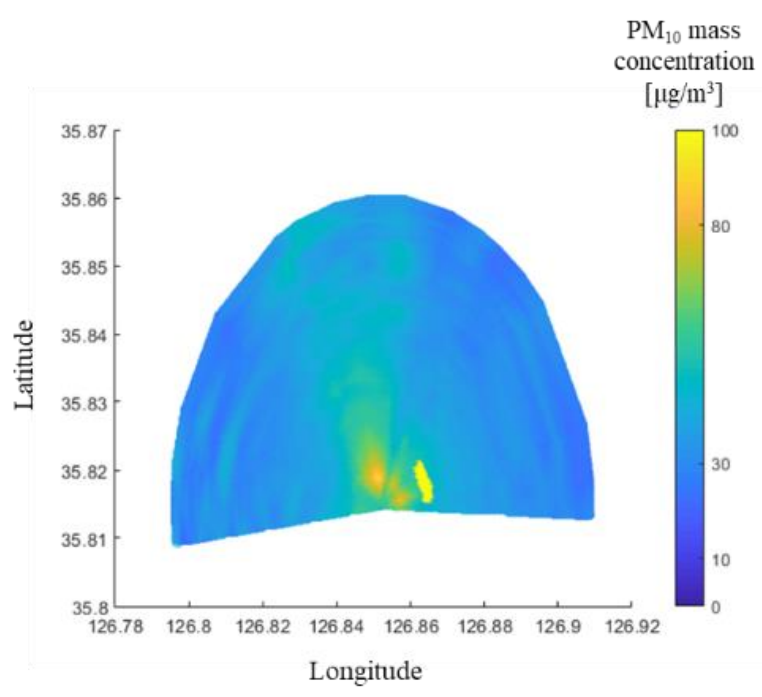


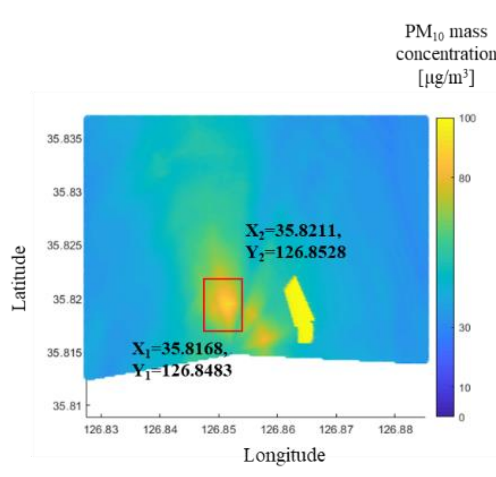
$$\bar{F}'_{PM_{10}\ or\ PM_{2.5}}(x,y) = \bar{C}'_{PM_{10}\ or\ PM_{2.5}}(x,y)\bar{U}(z)$$

$$F_{PM_{10}\ or\ PM_{2.5}} = \sum_{x=x_1}^{x=x_2}\sum_{y=y_1}^{y=y_2} \bar{F}'_{PM_{10}\ or\ PM_{2.5}}(x,y)\Delta x \Delta y$$

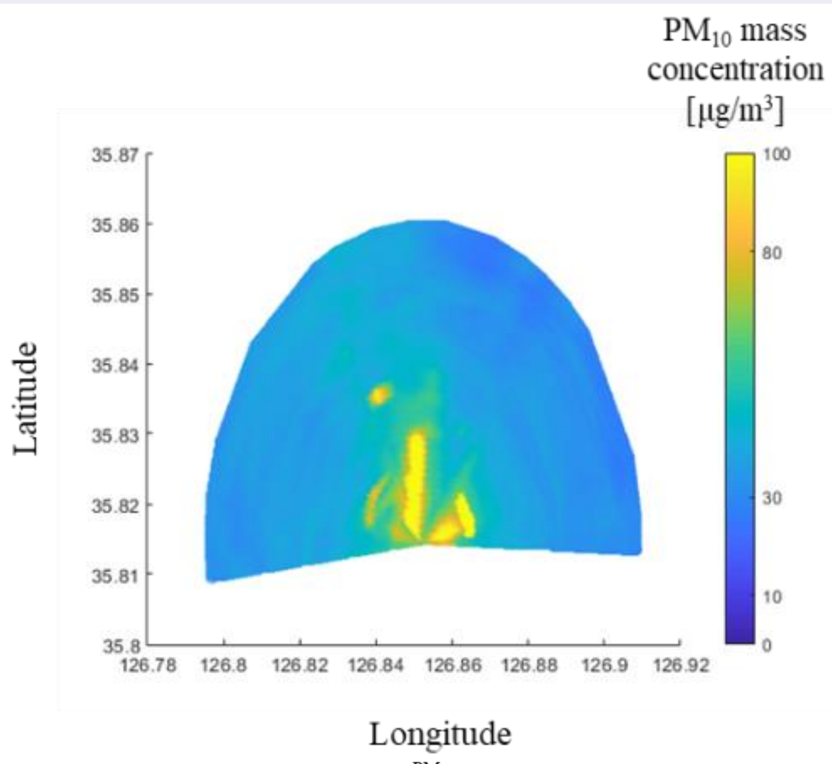
RESULTS

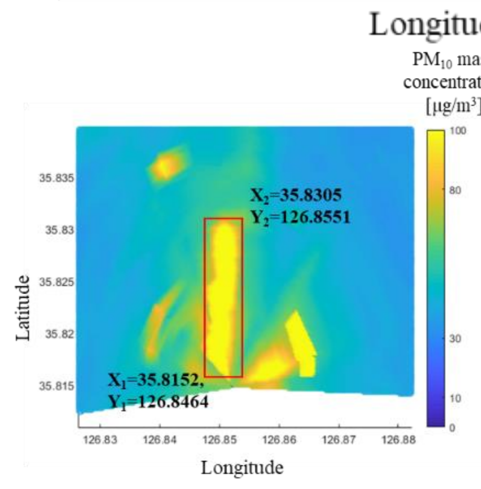
Case 1: stagnant plume





Case 2: dispersed plume





Values	Case 1		Case 2	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Mass concentration [$\mu g/m^3$] (average+s.d.)	42.6 ± 97.6	19.8 ± 47.4	43.4 ± 44.1	18.4 ± 20.2
Estimated flux [kg/h]	2.53	1.17	4.92	2.09

- Horizontal wind speed of case 1 and 2: 5.2 m/s
- We calculated the upward velocity using the relationship between the plume central velocity and mass entrainment rate in the plume rise model, then estimate the emission flux using mass concentration and plume distribution range. The emission fluxes of PM2.5 in stagnant and diffused cases were 1.17 kg/h and 2.09 kg/h, respectively. Annualized values of the emission flux were 0.11 tons/year and 0.20 tons/year according to the number of observations. These were slightly lower than the national emission inventory (4.98 tons/year). The difference might be because the emission inventory was overestimated or there were errors in the process of annualization.

Summary

• We tried to estimate the flux of agricultural burning using the mass concentration of PM. The measured flux is relatively higher than the calculated flux considering the emission factor, agricultural area scale, and the number of populations.

•We supposed that the higher measured flux might be because the scanning LIDAR can detect all kinds of burning aerosols.