Estimating Black Carbon Emissions from Biomass Burning

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January 4, 2017

Contents

Black Carbon (BC) is not directly reported by statewide emissions summaries.BC is a fraction of the Total Carbon (TC) component of Particulate Matter 2.5 μm (PM2.5). PM2.5 emissions are published annually by California Air Resources Board (CARB) (Criteria air pollutant (CAP) emissions estimates). By using the 2015 CAP emissions estimates shown in Table **??** with estimated ratios of smoldering to flaming combustion for hand/machine piled burns, prescribed natural fire and wildfire from **?**, Black Carbon emissions can be calculated from PM 2.5 with Eq. (1)

Source (CARB nomenclature)	Description	PM 2.5 (t y^{-1})
ALL VEGETATION	Wildfire	137630.15
FOREST MANAGEMENT	Pile burning	5480.51
WILDLAND FIRE USE (WFU)	Prescribed natural fire	6802.43

Using the 2015 Criteria Air Pollutants (CAP) emissions estimates shown in Table **??** with estimated ratios of smoldering to flaming combustion for hand/machine piled burns, prescribed natural fire and wildfire from **?**, BC emissions can be estimated from PM 2.5 using equation (1)

$$BC = (PM_{2.5} \times F \times TC_f \times BC_f) + (PM_{2.5} \times S \times TC_s \times BC_s) \tag{1}$$

where:

$$BC = \text{Black Carbon (mass units)}$$
$$PM_{2.5} = PM_{2.5} \text{ (mass units)}$$
$$F = \text{Percent of combustion in flaming phase}$$
$$TC_f = \text{Total Carbon fraction of } PM_{2.5} \text{ for flaming phase}$$
$$BC_f = \text{Black Carbon fraction of Total Carbon for flaming phase}$$
$$S = \text{Percent of combustion in smoldering phase}$$
$$TC_s = \text{Total Carbon fraction of } PM_{2.5} \text{ for smoldering phase}$$
$$BC_s = \text{Black Carbon fraction of Total Carbon for smoldering phase}$$

The ratio of smoldering to flaming combustion behavior for each biomass burning scenario means that each has a different BC Δ PM2.5 ratio. To arrive at a rough estimate of BC emissions based on PM2.5, ratios from **?** and **?** ratios in Table 1 are used herein.

Given the variance in BC production from smoldering ($\pm$ 49%) and flaming ($\pm$ 45%) phases (Table 1), actual emissions of BC may vary substantially depending on combustion. In addtion to these estimates **?** provides an alternative source for estimates of BC and Organic Carbon (OC) emissions in the state in 2006. Further work is necessary to evaluate the impacts of OC on the net Carbon Dioxide Equivalents (CO2e) emissions from pile burning. **?** estimated the absorptive properties of OC to be 1.5 - 2.5 that of BC. **?** estimated that on 2006 29,530 Mt of OC was emitted from wildfires.

Table 1: Factors used for calculating BC emissions from the three primary combustion sources. BC is a fraction of TC which is a fraction of total PM2.5. Coefficients of variation (C_v) are reported here as well.

combustion	context	TC t^{-1} PM2.5	TC$_{C_v}$ t^{-1} PM2.5	EC t^{-1} TC	EC$_{C_v}$ t^{-1} PM2.5	OC t^{-1} TC
f	p	0.621	0.07	0.023	0.15	0.598
f	wf	0.608	0.09	0.1108	0.506	0.4976
s	p	0.587	0.03	0.02	0.41	0.5675
s	wf	0.641	0.08	0.045	0.29	0.59625