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Supporting Information for

# Reconciling Assumptions in Bottom-up and Top-down Approaches for Estimating Aerosol Emission Rates from Wildland Fires using Observations from FIREX-AQ

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Table S1

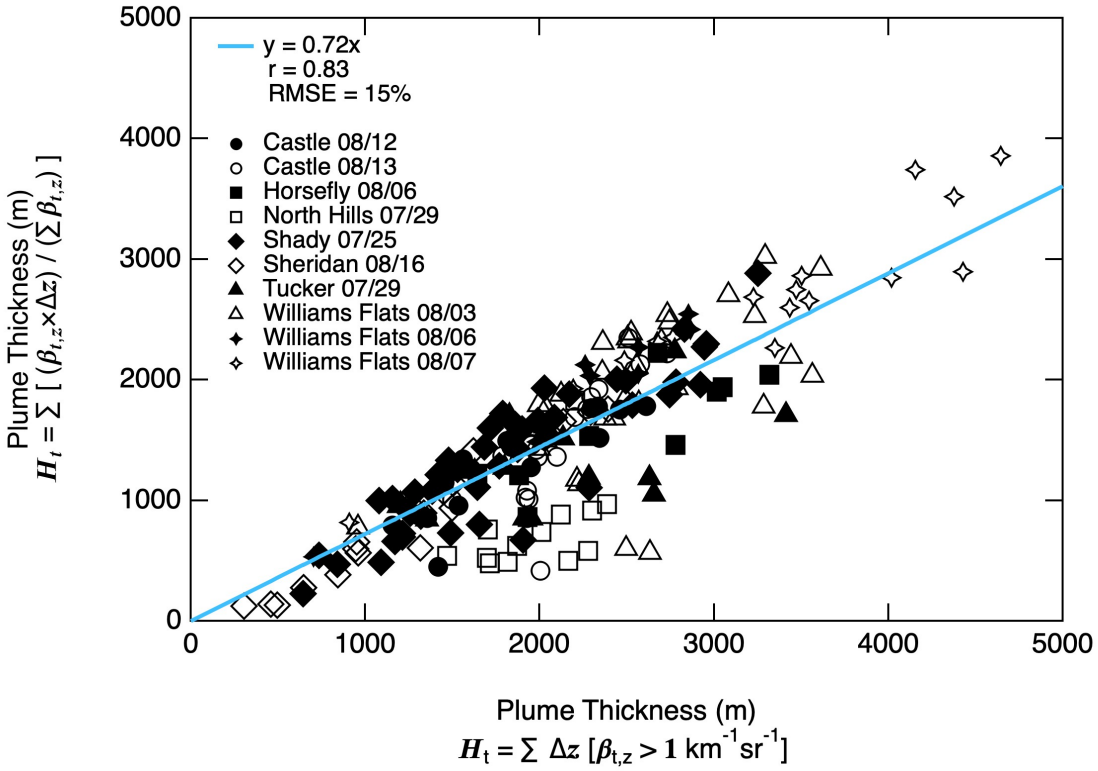


**Figure S1.** Relationship between two different methods to calculate plume thickness per transect for each fire. X-axis shows plume thickness calculated using equation 6 and y-axis shows plume thickness calculated as a function of the backscatter coefficient distribution throughout the HSRL curtain. Blue line shows the fit to a reduced major axis regression with a forced zero intercept. Pearson's correlation coefficient (r) and root mean square error (RMSE) are given in the legend.

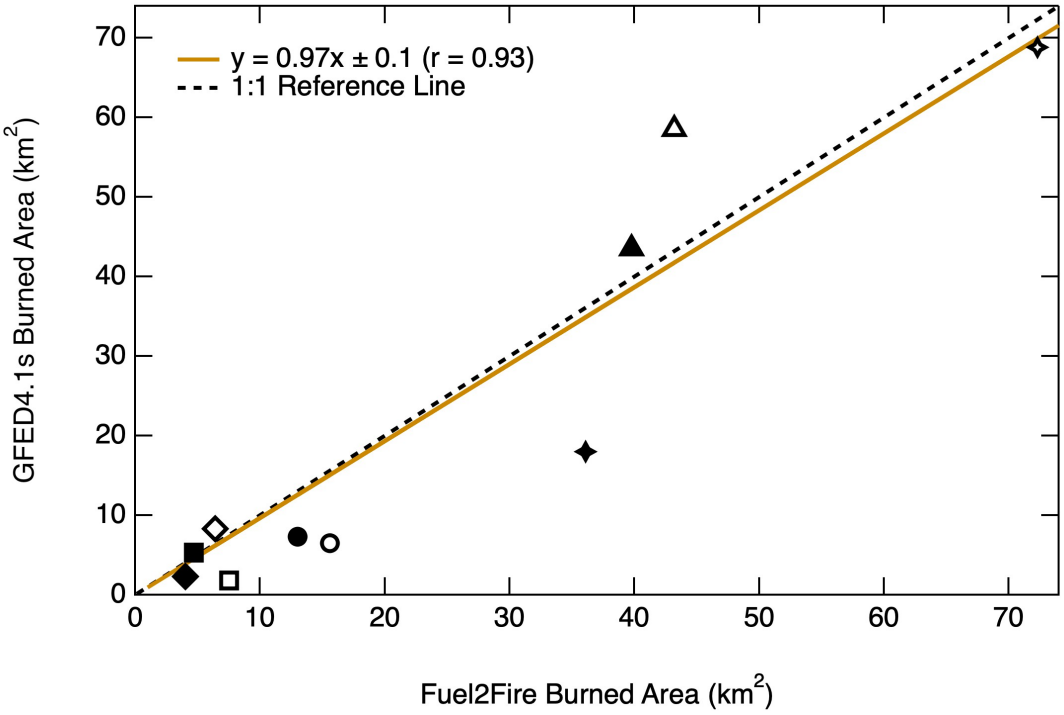


**Figure S2**. Total daily burned area per fire from Fuel2Fire versus GFED4.1s. The brown line shows the fit to a reduced major axis regression with a forced zero intercept. The slope and correlation coefficient are given in the legend. The black dashed line shows a perfect 1:1 relationship for reference.

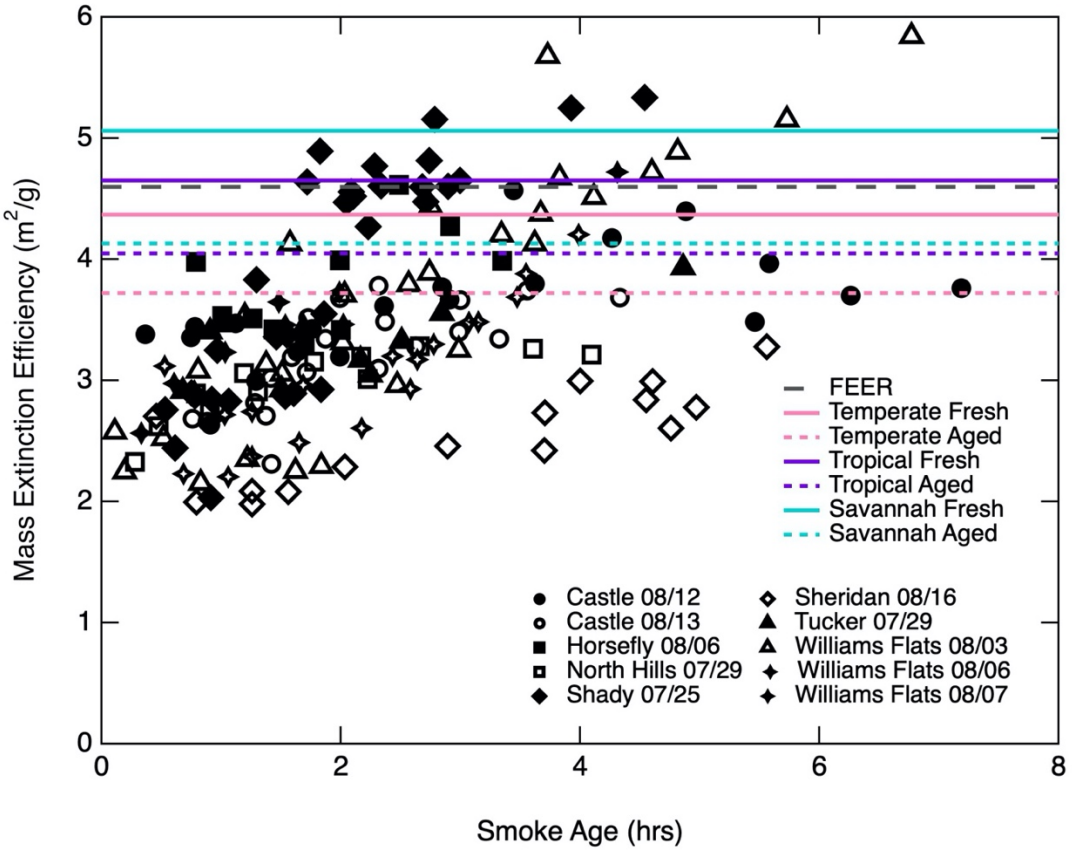


**Figure S3.** Mass extinction efficiency (MEE) calculated using in situ aircraft measurements for each fire per transect versus smoke age. Colored lines represent ecosystem average mass extinction efficiency for biomass burning particles taken from Reid et al. (2005b). Solid lines show MEE from fresh smoke (less than one day old) and dashed lines show MEE calculated using aged smoke (older than one day). The assumed MEE used by FEER is shown as the black dashed line.

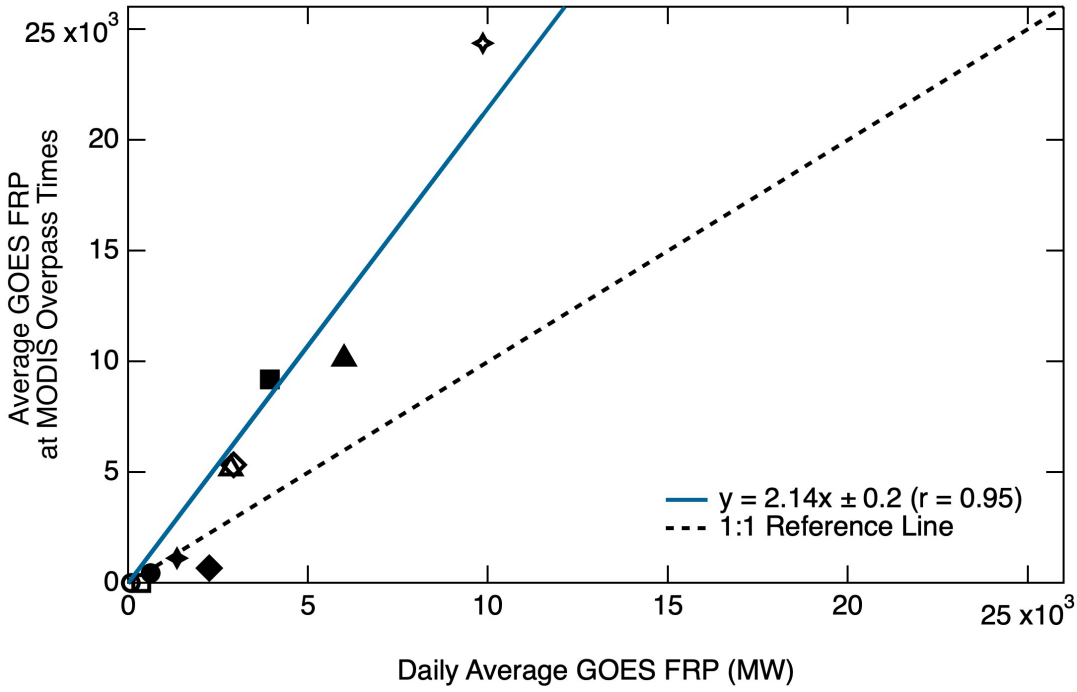


**Figure S4.** Daily average GOES FRP observations per fire versus average GOES FRP observations within 30 mins of the overpass times for MODIS onboard both Aqua and Terra per fire. The teal line shows reduced major axis regression line with the slope and correlation coefficient given in the legend. The black dashed line shows a perfect 1:1 relationship for reference.

| Approach | Variable Relative Error | | | $\mu \pm \sigma$ | IQR | Reference |
|---|---|---|---|---|---|---|
| GFED | $\delta E_{PM}$ = 126% | $\delta E_C$ = 120% | $\delta$BA = 44% | - | - | Giglio et al. (2018) |
| | | | $\delta$FL = 111% | 75 ± 83 | 130 | Van Leeuwen et al. (2014) |
| | | | $\delta$CC = 11% | 79 ± 9 | 14.0 | Van Leeuwen et al. (2014) |
| | | | $\delta$FC = 10% | 500 ± 5 | - | Akagi et al. (2011) |
| | | $\delta EF_{PM}$ = 36% | | 17.6 ± 6.4 | 7 | van der Werf et al. (2017) |
| FEER | $\delta E_{PM}$ = 78% | $\delta C_e$ = 73% | | 0.011 ± 0.008 | 0.008 | Ichoku and Ellison (2014) |
| | | $\delta$FRP = 27% | | - | - | Freeborn et al. (2014) |
| In Situ | $\delta E_C$ = 66%<br>$\delta E_{PM}$ = 75% | $\delta$WS = 17% | | 6 ± 1 | 4 | FIREX-AQ Observations |
| | | $\delta$GS = 3% | | 154 ± 5 | 16 | |
| | | $\delta$Ht = 28% | | 2121 ± 594 | 593 | |
| | | $\delta\Delta$C = 56% | | 0.009 ± 0.005 | 0.009 | |
| | | $\delta\Delta$PM = 67% | | 0.0006 ± 0.0004 | 0.001 | |
| Fuel2Fire | $\delta E_{PM}$ = 67% | $\delta E_C$ = 55% | | 1322 ± 729 | 510 | Fuel2Fire (Internal) |
| | | $\delta EF_{PM}$ = 38% | | 16 ± 6 | 7 | FIREX-AQ Observations |
| HSRL-GOES | $\delta E_{PM}$ = 78% | $\delta C_e$ = 67% | | 0.006 ± 0.004 | 0.005 | FIREX-AQ Observations |
| | | $\delta$FRP = 40% | | - | - | Li et al. (2020) |

**Table S1.** Relative uncertainty ($\delta$) given as a percentage for $E_{PM}$ and $E_C$ (when available) derived using GFED, FEER, in situ measurements, Fuel2Fire, and HSRL-GOES. From left to right the dependent variables are broken down into the individual independent variables required for their calculation. Relative uncertainty for each independent variable is calculated as the standard deviation ($\sigma$) divided by the mean ($\mu$), and relative uncertainty for each dependent variable is computed by error propagation through the equation by which they are defined. If the mean and standard deviation are not available, the relative uncertainty for a variable is taken directly from the corresponding reference. Mean, standard deviation, and interquartile range (IQR) are derived from aircraft observations during smoke plume transects and averaged over all the Western US wildland fires included in this study or calculated based on data from previous studies when available.