

Emissions of trace organic gases from western U.S. wildfires based on WE-CAN aircraft measurements

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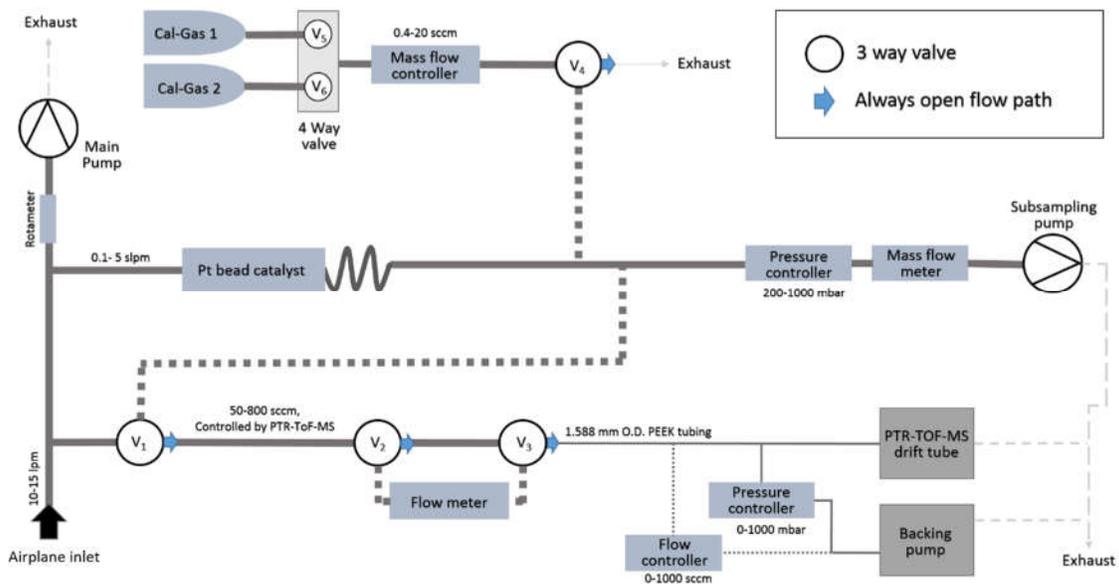


Figure S1.

Schematic of PTR-ToF-MS inlet configuration, zero air generator, and in flight calibration system during WE-CAN. All tubing is 3.175 mm I.D. PFA tubing except where shown to decrease to 1.588 mm O.D. PEEK tubing. The flow path during sampling is shown with the solid lines with typical flow rates indicated, while the dashed lines represent flow pathways used during calibration and instrument backgrounds.

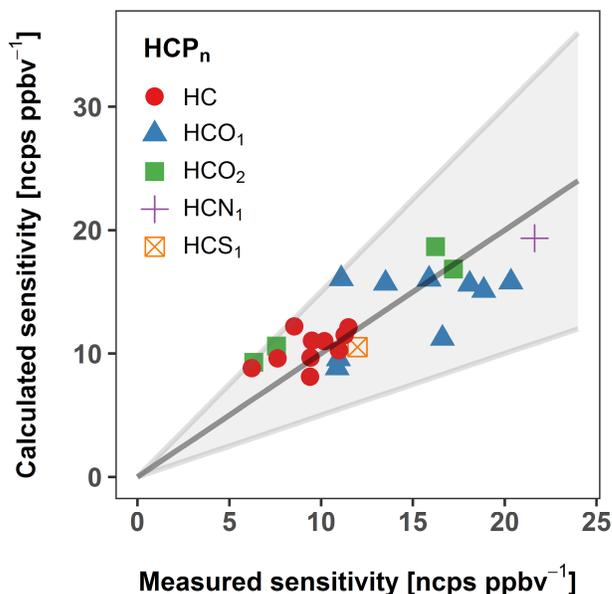


Figure S2.

Measured sensitivities for species directly calibrated using standard gases during WE-CAN, compared to sensitivities calculated using molecular properties following Sekimoto et al. (2017). Calibrated VOCs are shown by their elemental compositions, HCP_n, where HC stands for the hydrocarbon part and P_n represents the species and number of electronegative atoms in the compound. Thus, HC represents species only containing hydrogen and carbon (alkynes, terpenes, aromatics), HCO₁ represents species with one oxygen (alcohols, ketones, aldehydes, furans), HCO₂ represents two oxygens (formic acid, acetic acid, and furaldehydes), HCN₁ is acetonitrile, and HCS₁ is dimethyl sulfide. The shaded regions represent ±50 % uncertainty from the one-to-one line (dark grey). Directly-calibrated species include methanol, propyne, acetonitrile, acetaldehyde, formic acid, 1-butene, acetone, acetic acid, dimethyl sulfide, furan, isoprene, methyl vinyl ketone, methacrolein, methyl ethyl ketone, benzene, 2-methyl furan, toluene, 2-furfural (furaldehyde), 3-hexanone, ethylbenzene, *m*-xylene, 5-methyl furfural, C₉ aromatics (1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene), 1,2,3,5-tetramethylbenzene, and α-pinene.

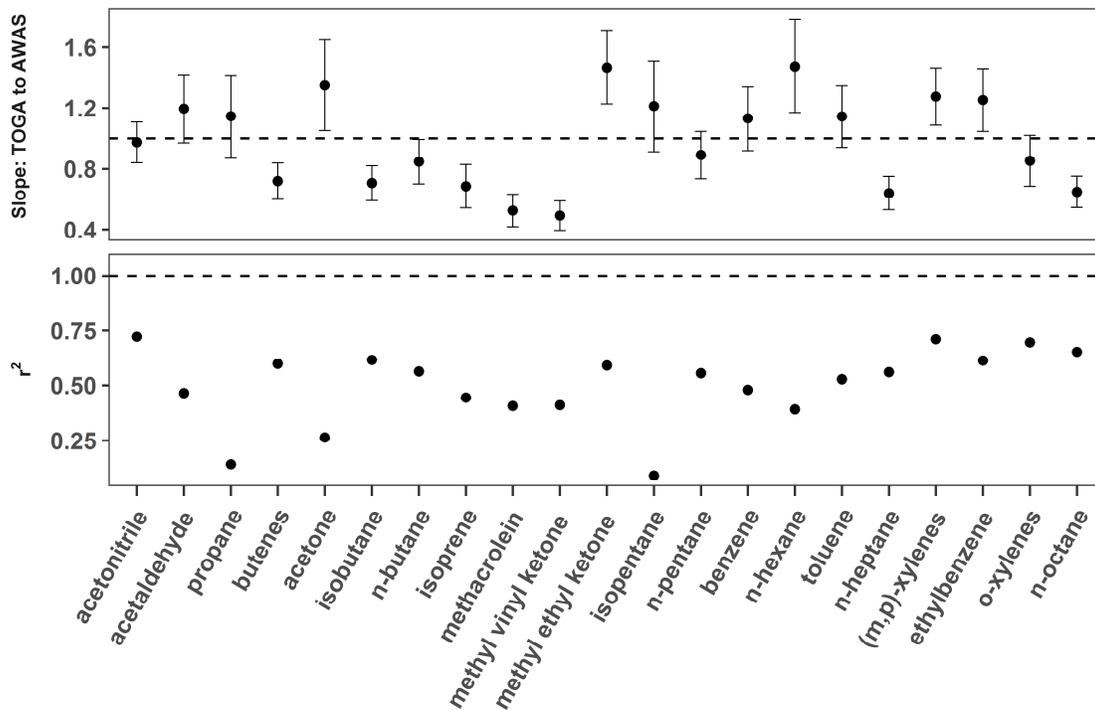


Figure S3.

Slope and correlation coefficients (r^2) of the reduced major axis regression of TOGA versus AWAS emission ratios, for 15 'unique fires' used in this work. Slopes < 1 mean that TOGA measured values are higher than AWAS values. Error bars show the standard error of the slope. AWAS measured 3-methylpentane $\sim 10\times$ higher than TOGA and has been removed from the plot to preserve the y-axis scale. The poor slope comparison is partially due to the fact that 3-methylpentane is enhanced only slightly in the wildfires compared to the other observed alkanes. Butenes include TOGA isobutene and 1-butene compared with AWAS 1-butene, cis-2-butene, and trans-2-butene.

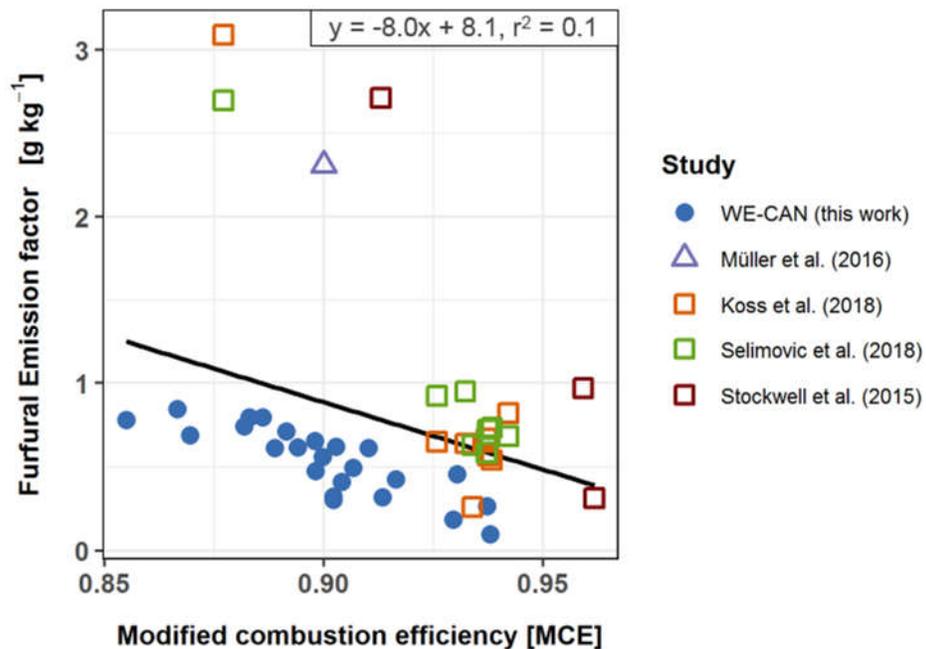


Figure S4.

Correlations of WE-CAN furfural EFs versus MCE, along with EFs for one field campaigns (Müller et al., 2016) and coniferous fuels measured during three laboratory burns (Koss et al., 2018; Selimovic et al., 2018; Stockwell et al., 2015). The black line represents the least squares regression for all studies.

Caption for Table S1.

Summary of measurements used in this work. VOC contributors for PTR-ToF-MS ions and isomeric fractional contributions are from Koss et al. (2018) except for green colored contributions which were determined from WE-CAN data using TOGA speciated measurements. VOCs that are reported for additional speciation information but were not used in the total carbon or total emissions calculations are shown in italics. PTR-ToF-MS VOCs with direct calibrations are shown in red, while the remaining were calculated using the method described by Sekimoto et al. (2017).

Caption for Table S2.

Emission factors (g kg^{-1}) for each of the 24 'unique fires' used in this work. Uncertainties are reported as the standard deviation (1σ) of averaged plume transects when available. *Note.* ^aNumber of emission transects sampled < 30 minutes apart and averaged together for each 'unique fire'. ^bDominant/Primary isotopologue exact mass. ^cVOC contributors to PTR-ToF-MS measured ion masses are assigned based on Koss et al. (2018) and listed in order of most abundant isomeric contribution. Italicized VOC contributors are shown for speciation purposes but not included in the total carbon term of the carbon mass balance nor total emissions calculations (Section 2.4). ^dTrace organic gas analyzer (TOGA). ^eAdvanced whole air sampler (AWAS). ^fIodide-adduct time-of-flight chemical-ionization mass (I⁻ CIMS). ^gSingle particle soot photometer (SP2). ^hHigh-resolution aerosol mass spectrometer (HR-AMS).

Caption for Table S3.

Emission ratios for each of the 24 'unique fires' used in this work ($\text{ppb ppm}^{-1} \text{CO}$, except for black carbon and organic aerosol which are reported as $\mu\text{g sm}^{-3} \text{ppm}^{-1} \text{CO}$). Uncertainties are reported as the standard deviation (1σ) of averaged plume transects when available. *Note.* ^aNumber of emission transects sampled < 30 minutes apart and averaged together for each 'unique fire'. ^bDominant/Primary isotopologue exact mass. ^cVOC contributors to PTR-ToF-MS measured ion masses are assigned based on Koss et al. (2018) and listed in order of most abundant isomeric contribution. Italicized VOC contributors are shown for speciation purposes but not included in the total carbon term of the carbon mass balance nor total emissions calculations (Section 2.4). ^dTrace organic gas analyzer (TOGA). ^eAdvanced whole air sampler (AWAS). ^fIodide-adduct time-of-flight chemical-ionization mass (I⁻ CIMS). ^gSingle particle soot photometer (SP2). ^hHigh-resolution aerosol mass spectrometer (HR-AMS). ⁱ $\mu\text{g sm}^{-3} \text{ppm}^{-1} \text{CO}$

Caption for Table S4.

Emission pass start and stop times for the 24 'unique fires' used in this work. Times are reported in UTC. Enter and exit times correspond to when the C-130 entered and exited a smoke plume used for the emission analysis in this work. Emission transects > 30 minutes apart are treated as 'unique fires' and denoted with a, b, c, etc. 'Unique fires' with multiple emission transects that were averaged together are shown as pass 1, pass 2, etc.

Caption for Table S5.

Linear regression statistics for EF vs. MCE correlations for the 151 VOCs with EFs measured in at least 10 of the 24 'unique fires'.