Understanding of Volatile Organic Compound Emissions from Western US Wildfires

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Biomass burning is a large source of volatile organic compounds (VOCs) and many other trace species to the atmosphere. These VOCs can act as precursors to formation of secondary pollutants such as ozone and fine particles, and some VOCs can also have direct effects on human and ecosystem health. Multiple different and complex processes take place in biomass burning, e.g., distillation, flaming, and smoldering combustion processes. In a given fire, most of these processes occur simultaneously, but the relative importance of each can change over the course of a fire. This gives rise to some of the variability in VOC emissions between different fires. To study gas-phase emissions from biomass burning in western US, a proton-transfer-reaction time-of-flight mass spectrometry (PTR-ToF-MS) was deployed during the FIREX 2016 laboratory intensive (at the US Forest Service Fire Sciences Laboratory in Missoula, Montana) and the FIREX-AQ field campaign (https://csl.noaa.gov/projects/firex-aq/). Measurements performed with the PTR-ToF-MS were analyzed with positive matrix factorization (PMF) to parameterize the VOC emissions. The results are summarized as follows:

1. Despite the complexity and variability of emissions, a PMF solution including just two emission profiles explained on average 85% of the VOC emissions across 15 different fuel types including pines, firs, spruce, grass, shrubs, chaparrals, and wood wool.
2. The two profiles were identified as resulting from high-temperature and low-temperature pyrolysis processes, and the profiles were remarkably similar (correlation coefficient $r > 0.9$) across nearly all the fuel types described in 1).
3. The VOC emissions from real-world wildfires were described on average of 80% by just three emission profiles, i.e., (i) high-temperature profile, (ii) low-temperature profile, and (iii) a profile related to chemical aging.
4. Contributions of high-temperature profile, low-temperature profile, and aging profile can be parameterized using fire radiation power and emissions of maleic anhydride and furan.

Keywords: Volatile organic compound, Wildfire, Proton-transfer-reaction mass spectrometry (PTR-MS)

