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Ground solar absorption observations of total column CO, CO_2, CH_4, and aerosol optical depth from California's Sequoia Lightning Complex Fire: emission factors and modified combustion efficiency at regional scales

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Description of EM27/SUN measurements in the San Joaquin Valley during September 2018 and 2019

September 2018 and 2019 measurements in the San Joaquin Valley took place over 5 to 6 days in each year. Total column averages of CO, CO_2, and CH_4 were measured continuously between 9 am and 6 pm at northwest (NW) and southwest (SE) locations with the Los Alamos National Laboratory (LANL) and NASA Jet Propulsion Laboratory (NASA-JPL) EM27/SUNs. The NW and SE observational sites were chosen to target dairy farms in the area north of Visalia, CA. The NW location was consistent between measurement days, while the SE location varied per day dependent on forecasted winds to maximize sensitivity to dairies of interest (Figure S1).

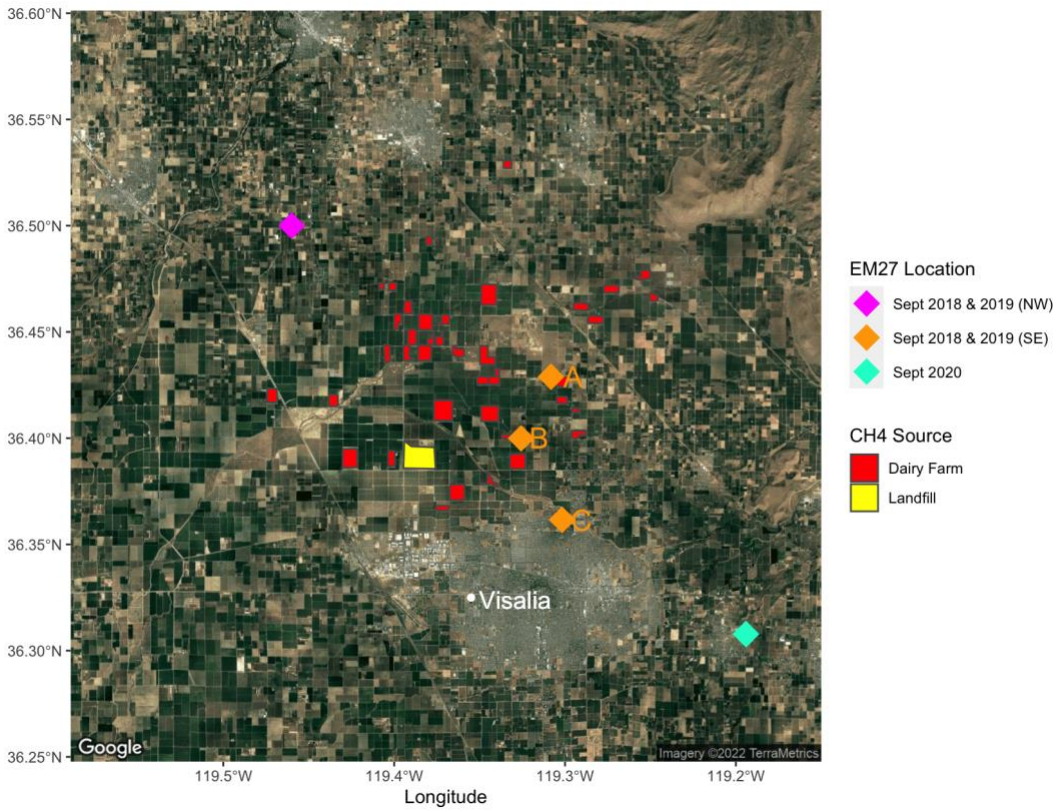

Figure S1. EM27/SUN observational sites at NW and SE and targeted dairy farms (red). Sources of methane in this area include dairy farms and a landfill (yellow).

Background estimation of EM27/SUN measurements

The enhancement over background (ΔX_{gas}) was calculated by subtracting the background ($X_{gas,\ bkdg}$) determined as the 2nd percentile of the daily measured mixing ratios (X_{gas}). Due to ongoing wildfires throughout the state, TCCON stations in Southern California (Caltech and NASA Armstrong/Dryden) were inappropriate as background sites. We used TROPOMI satellite retrievals of X_{CO} on the Sept. 12 plume event as a case study to determine whether a 2nd percentile subtraction is appropriate to calculate the background.

TROPOMI satellite measurements can provide a better spatial understanding of heterogenous emissions during events like the large scale wildfire plume. During the day on Sept. 12, the EM27/SUN measured a background of 220 ppb determined by the 2nd percentile (green line, Figure S2a). From TROPOMI observations, we can see that south of the plume was relatively "cleaner" while north of the plume X_{CO} levels were higher (Figure S2b and Figure S2c) due to emissions of multiple wildfires burning in the Sierra Nevada flowing southward. On this day, the EM27/SUN did not reach lower X_{CO} levels as observed by TROPOMI and in Figure S2c we can see that the appropriate background for the EM27/SUN is determined by the instrument itself as the 2nd percentile.

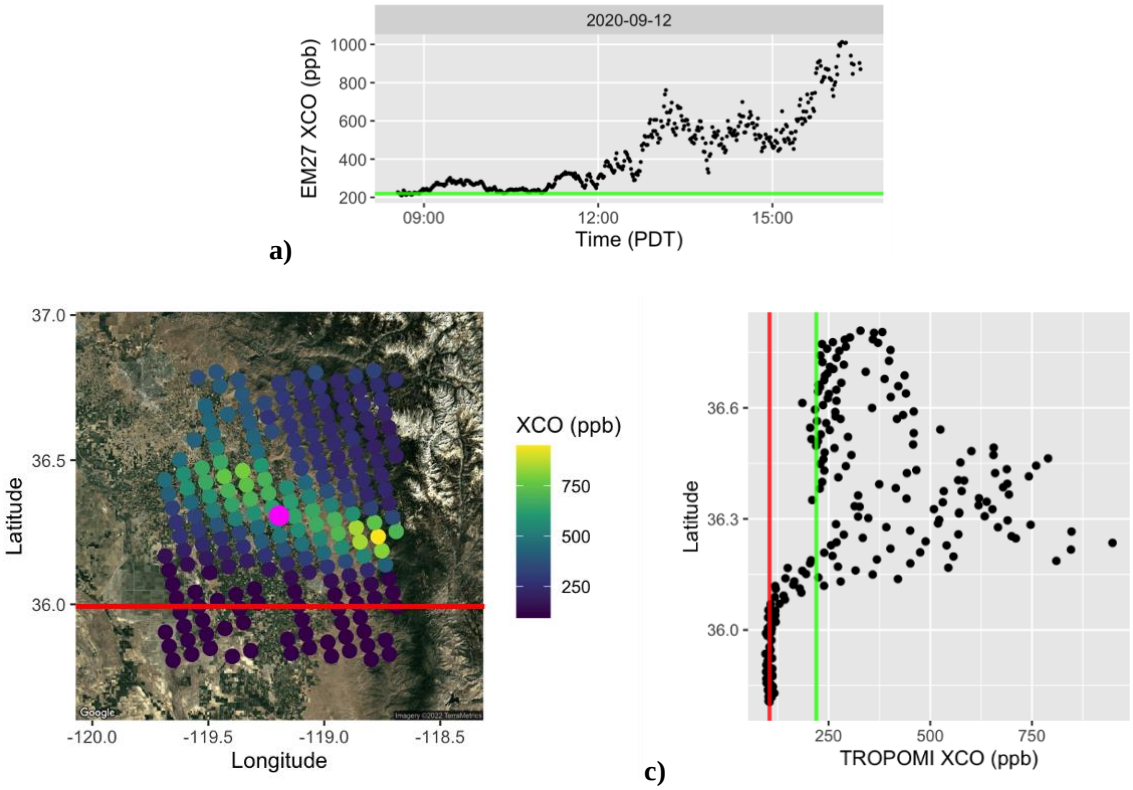

Figure S2. a) EM27/SUN timeseries of Sept. 12 plume event with green line representing the background (220 ppb) determined as the 2nd percentile of the daily measurements. b) TROPOMI satellite X_{CO} retrievals of Sept. 12 plume event with location of EM27/SUN displayed with a magenta marker and a red line marking the 36° latitude line. c) Latitudinal TROPOMI X_{CO} with red line showing the average 105 ppb X_{CO} below the 36 latitudinal line and the green line at 220 ppb displaying the background determined from the EM27/SUN 2nd percentile daily measurement.

Comparison of AERONET and FTIR derived AOD at 500 nm

The FTIR-derived AOD at 500 nm was compared to an AERONET site located ~90 km north. We average hourly the AOD at 500 nm values for this comparison. A type II linear regression was fit to the points.

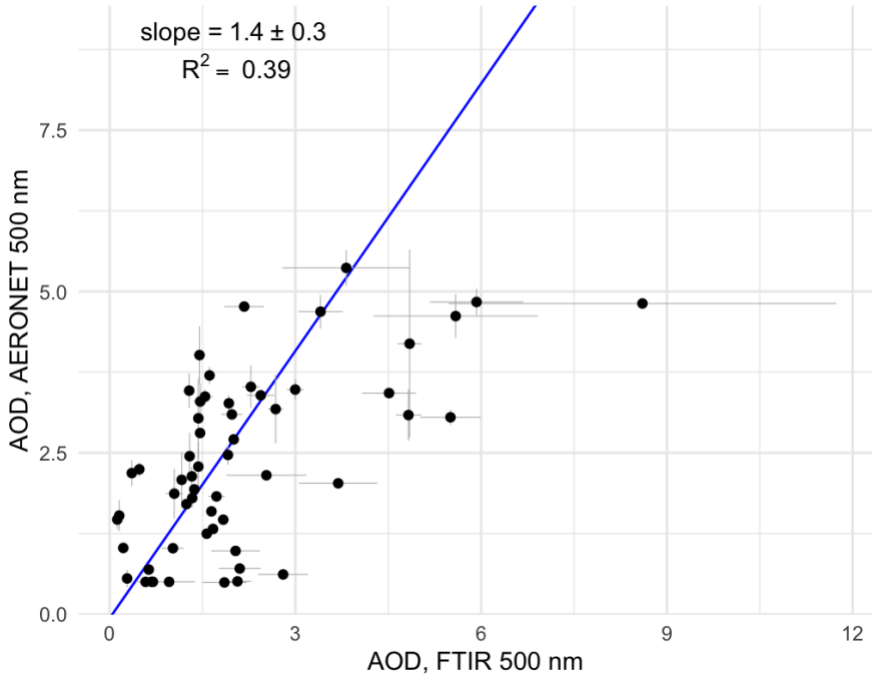

Figure S3. Comparison of the AERONET and FTIR AOD observations from Sept. 8 – 15.

References:

D. Kahle and H. Wickham. ggmap: Spatial Visualization with ggplot2. The R Journal, 5(1), 144-161. URL http://journal.r-project.org/archive/2013-1/kahle-wickham.pdf