

## Measurement Capabilities of the CU SOF Instrument: Separation of Methane Emissions from Agricultural and Natural Gas Sources & Developing Techniques to Quantify Wildfire Emissions

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This proof-of-concept study demonstrates that methane ( $\text{CH}_4$ ) emissions from natural gas (NG) and agriculture can be disentangled using the concept of excess column observations. The University of Colorado Solar Occultation Flux (CU SOF) instrument and three Collaborative Carbon Column Observing Network (COCCON) instruments were set up across Colorado's Front Range. This network of cost-effective sensors measured excess column-averaged, dry-air mole fractions for  $\text{CH}_4$  ( $\Delta\text{XCH}_4$ ; measured by COCCON), ethane ( $\Delta\text{XC}_2\text{H}_6$  as NG tracer; measured by CU SOF), and ammonia ( $\Delta\text{XNH}_3$  from agriculture; measured by CU SOF) in the Denver-Julesburg Basin during March 2015.  $\Delta\text{XCH}_4$  varied up to 17 ppb, and was > 3 times higher with winds from directions where NG is produced. The  $\Delta\text{XCH}_4$  variance is explained by variations in the  $\text{C}_2\text{H}_6$ - $\text{NH}_3$  tracer pair, attributing  $63 \pm 17\%$  to NG,  $25 \pm 10\%$  to agriculture, and  $12 \pm 12\%$  to other sources. The ratios  $\Delta\text{XC}_2\text{H}_6/\Delta\text{XCH}_4$  ( $16 \pm 2\%$ ; indicates wet NG), and  $\Delta\text{XNH}_3/\Delta\text{XCH}_4$  ( $43 \pm 12\%$ ) were compatible with *in situ*-measured ratios. Excess columns are independent of boundary layer height, characterize gases in the open atmosphere, are inherently calibrated, averaged over extended spatial scales, and provide a complementary perspective to quantify and attribute  $\text{CH}_4$  emissions on regional scales.

An airborne version of the CU SOF instrument was deployed on research aircraft to quantify wildfire emissions during the 2018 wildfire season in the Pacific Northwest (BB-Flux project). We show that column measurements can be used to quantify emission fluxes from wildfires as well.



**Figure 1.** In Colorado, oil and gas operations sit within feet from cattle farms. Photo credit: Frank Flocke/ NCAR



**Figure 2.** One of the COCCON instruments measuring  $\text{CH}_4$  at the main measurement site inside the Denver-Julesburg Basin. CU SOF, deployed in the trailer, measured the NG and agricultural tracers.