Trends in Methane Emission Sources in the Los Angeles Basin, CA from 2010–2023

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I. Introduction

- Methane (CH_4) is a potent greenhouse gas (GHG) with a short lifetime (~10 yrs).
- California (CA) legislation requires CH_4 emissions be reduced by 40% below 2013 levels by 2030.
- CH_4 emissions in the South Coast Air Basin (SoCAB) in CA (Fig. 1) have been the subject of many recent studies but often lack knowledge on the source of emissions.
    - SoCAB comprises around 45% of the CA population
- This study follows the methods of Peischl et al. (2013) to utilize in situ airborne CH_4 and light alkane data to quantify the source apportionment of summertime CH_4 emissions in the L.A. Basin over the past 13 years.

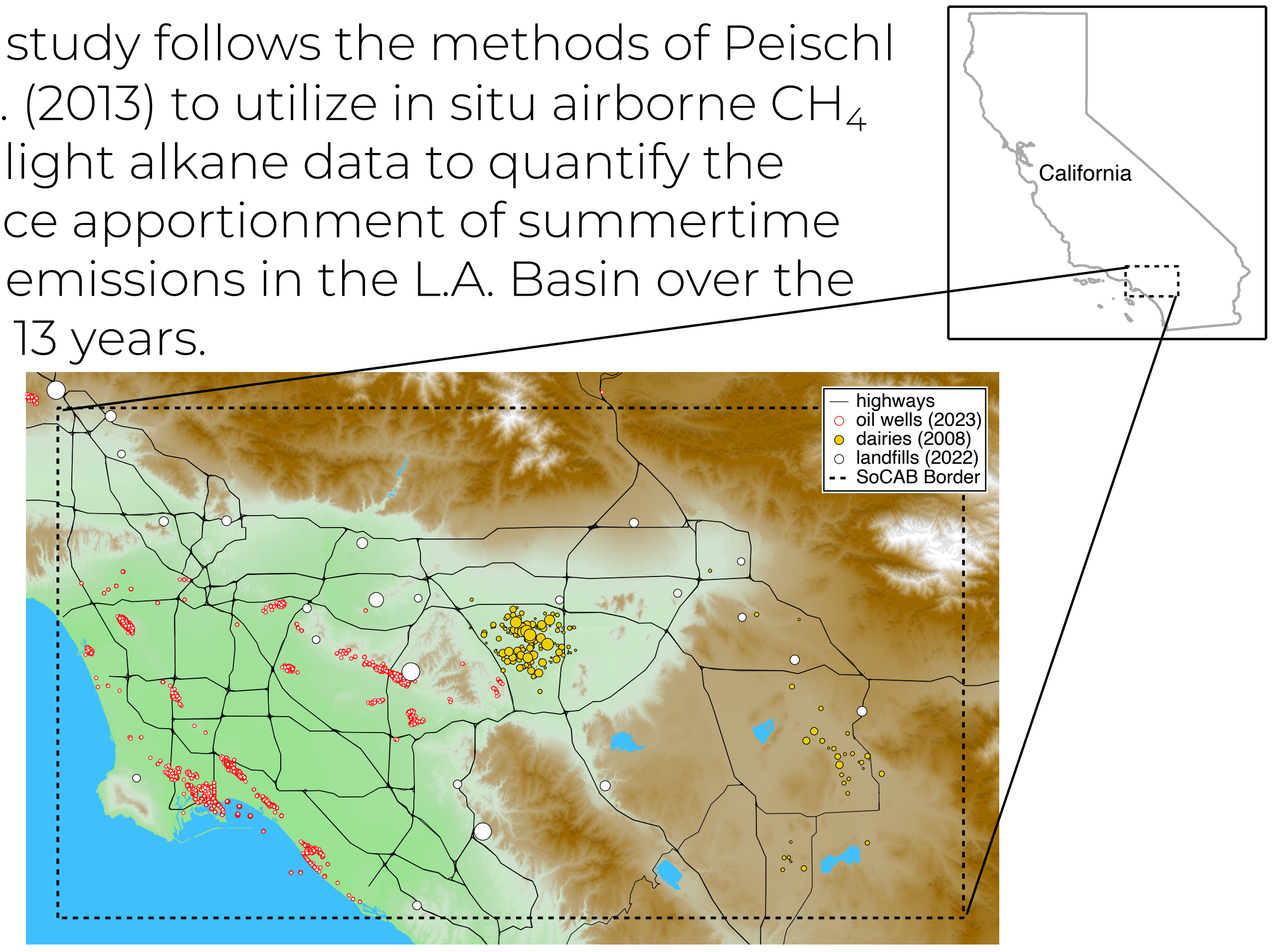

Figure 1. Map of CA and SoCAB subset area; possible L.A. Basin CH_4 point sources are marked on the map, with dashed box around the area used in this analysis.

II. Methods & Data

- In situ measurements of trace gases (C_1–C_5 alkanes, CO, & CO_2)
    - NOAA P-3 (CalNex, 2010) and NASA DC-8 (FIREX-AQ, 2019 & AEROMMA, 2023) aircraft
- Emission rates of CH_4 in L.A. Basin calculated from:
    - Experimentally determined alkane/CO or alkane/CO_2 emission ratios (Fig. 2)
    - Annual CO inventory from the California Air Resources Board (base year: 2017) or ODIAC CO_2
    - Extrapolated to yearly emissions (*note*: Zeng et al. (2023) found minimum CH_4 emissions in SoCAB in summertime)

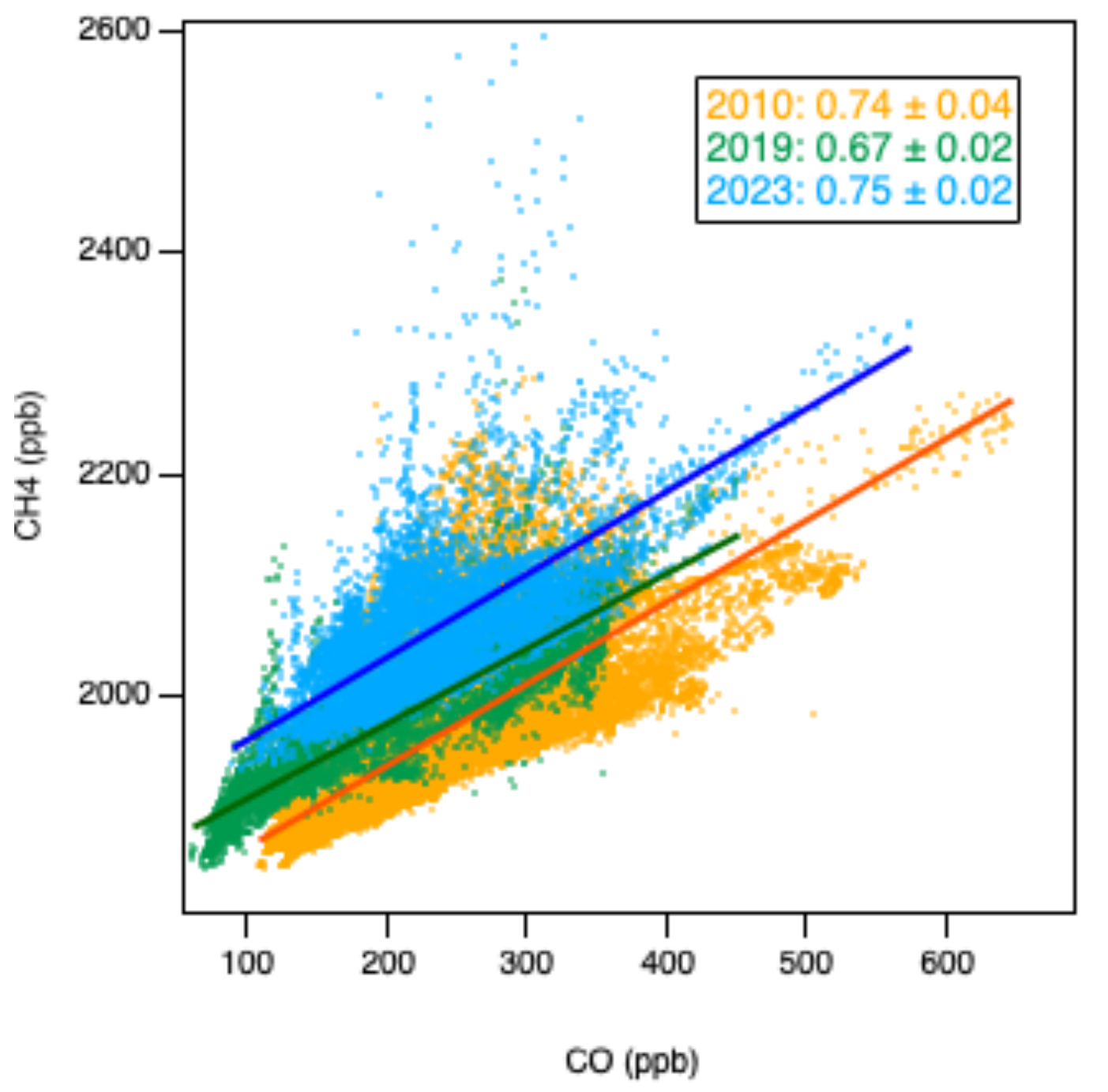

Figure 2. Plot of CH4 vs CO data for all three years, with emission ratios listed; similar plots were generated for each alkane/CO.

- Solve system of linear equations (eq. 1) for source apportionment of CH_4 in the L.A. Basin for 2010, 2019 and 2023 (Fig. 2):

Ex.

$$\begin{array}{r} \\ CH_4 \\ \text{ethane} \\ \text{propane} \\ \dots \end{array} \overset{\text{source 1} \quad \text{source 2} \quad \text{source 3} \quad \dots}{\begin{bmatrix} a & b & c & \dots \\ d & e & f & \dots \\ g & h & i & \dots \\ \dots & \dots & \dots & \dots \end{bmatrix}} \times \overset{\text{fraction of sources}}{\begin{bmatrix} x \\ y \\ z \\ \dots \end{bmatrix}} = \overset{\text{observed total emission rates in SoCAB}}{\begin{bmatrix} E_{CH4}= ax+by+cz+\dots \\ E_{ethane}= dx+ey+fz+\dots \\ E_{propane}= gx+hy+iz+\dots \\ \dots \end{bmatrix}} \quad (1)$$

Alkane abundance in sources from published work

Solve for

Experimentally determined alkane/CO × inventory CO

Analysis of **in situ airborne** measurements provide insights into **annual changes in alkane emission sources** from L.A. Basin.

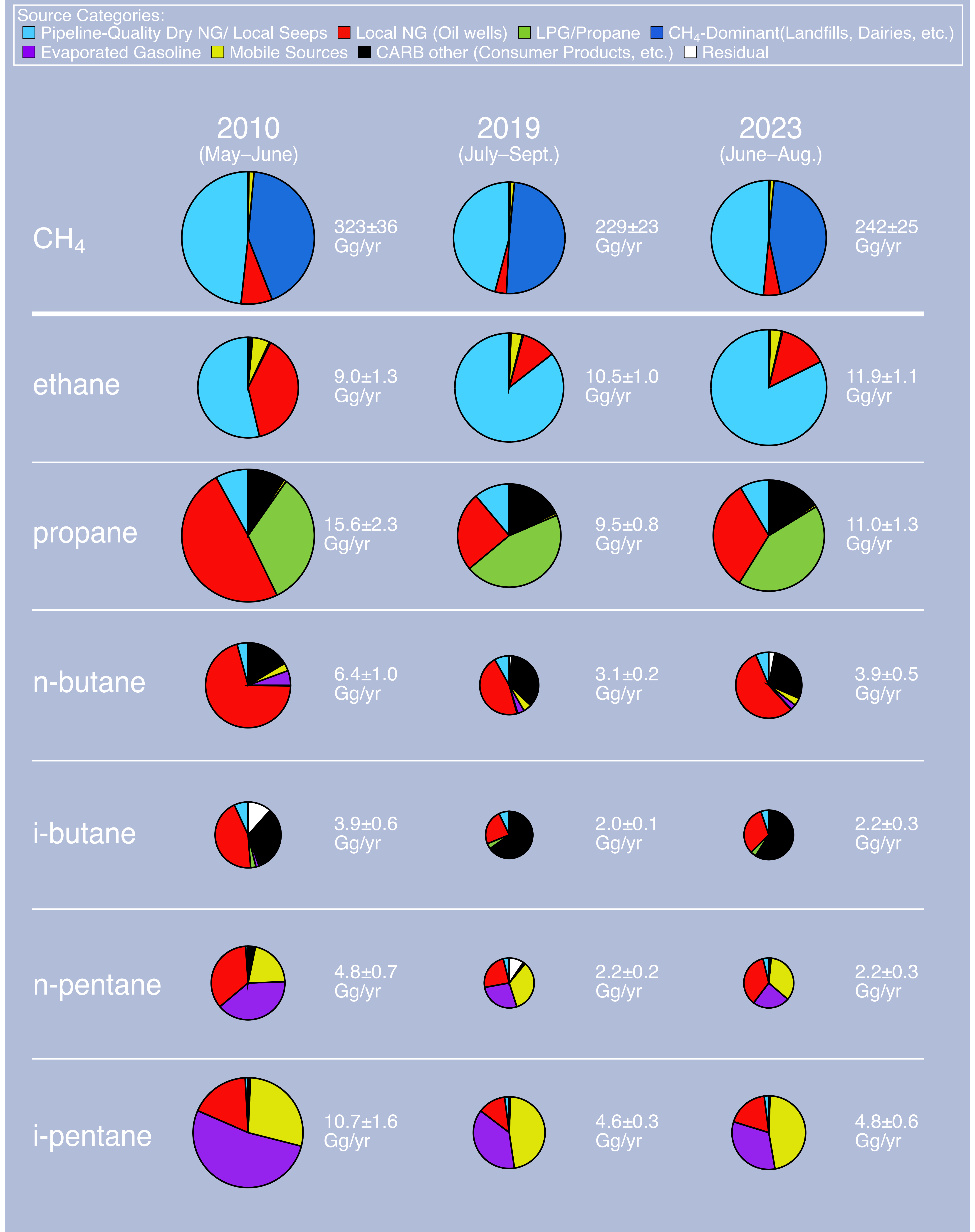

Figure 3. Results from a linear least squares solution to a combination of six emission sources and seven trace gas species (eq. 1) in the SoCAB over three years (2010, 2019, 2023). Pie chart areas normalized by total emissions relative to 2010 CH_4 for all CH_4 pie charts and relative to 2010 propane for the rest of the alkanes.

III. Results & Discussion

- Total CH_4 **emissions decreased at a rate of –6.4 ± 3.3 Gg/yr² since 2010** (Fig. 4), while the source apportionment remained fairly consistent (Fig. 3).
    - Local natural gas (NG) emissions are ascribed to emissions of **13.5% of the local production in 2010** and **9.4% in 2019.**
    - Pipeline-Quality Dry NG/Local Seep emissions represent **2% of the NG distributed to the basin all 3 years.**
    - Zeng et al. (2023) found an annual decrease of between –4.2 to –8.2 Gg/yr CH_4 emissions in L.A. Basin from 2011–2020 based on monthly CLARS CH_4/CO_2 ratio and ODIAC & CARB CO_2 inventories (Fig. 4).
    - Kuwayama et al. (2019) attributed 56-79% of CH_4 emissions in SoCAB from 2014–2016 to NG sources, roughly in line with our findings of 49%-56% (Pipeline + local NG CH_4) between 2010–2023.

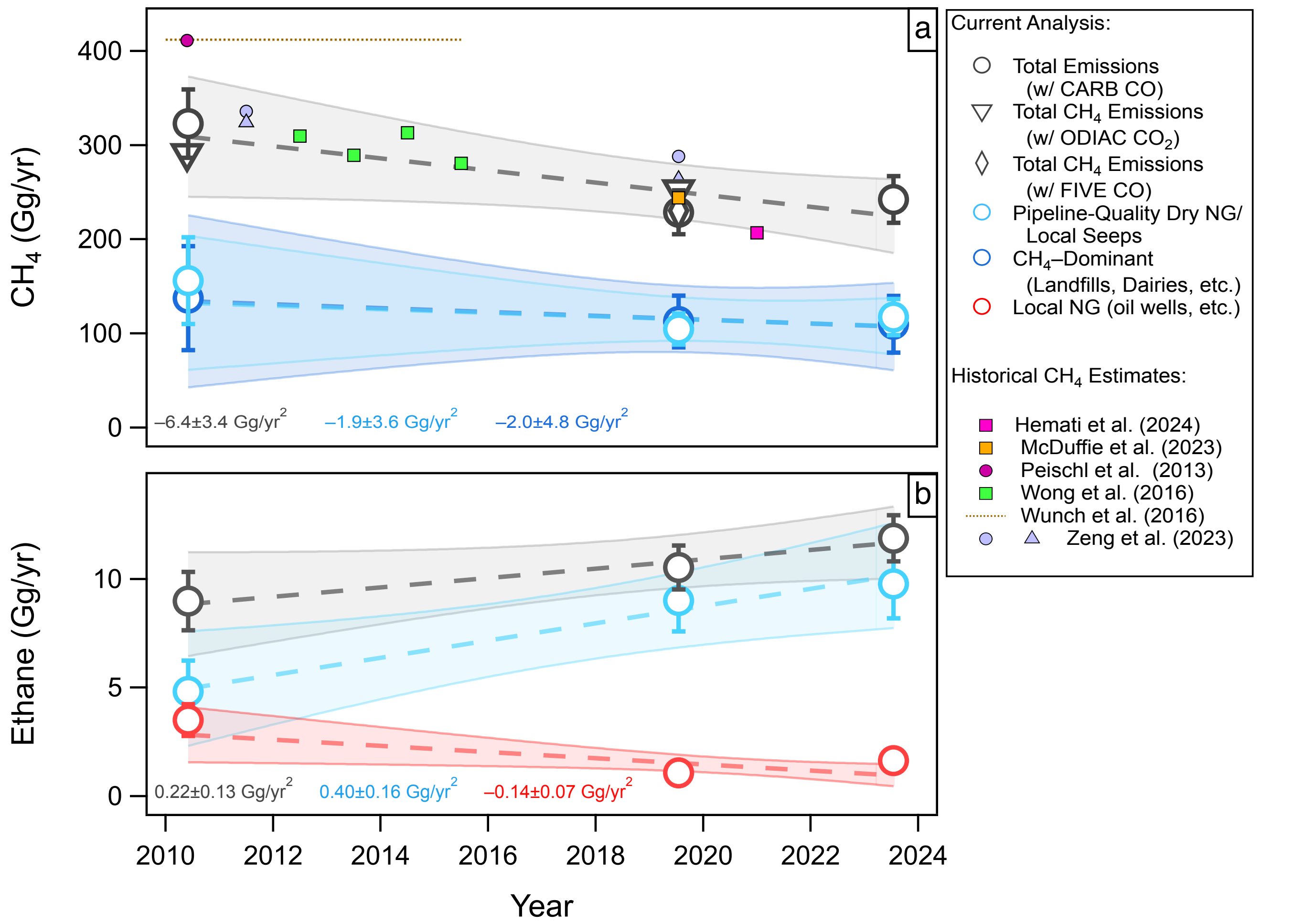

Figure 4. Plots of (a) total observed and largest source emissions for CH_4 and (b) ethane vs. time, with linear fits applied and slopes listed below. Historical CH_4 emissions from the literature are additionally shown in plot a.

- **Ethane emissions increasing since 2010, with significant changes in source composition** (Fig. 3 & 4).
    - Wunch et al. (2016) also found ethane increasing in SoCAB from 2010–2016.
    - Ethane/CH_4 ratio in pipeline-quality NG composition increased from 2010–2023, possibly due to decreasing ethane prices (Wennberg et al. (2012).
- For pentanes, **evaporated gasoline emissions decreased from 2010–2023.**
    - Evaporated gasoline i-pentane emissions represent 1.2% of LA gasoline sales extrapolated to the SoCAB in 2010 and 0.4% in 2019 and 2022.

IV. Future Work

- Further comparison of top-down to bottom-up estimates, and CO/CO_2 inventories.
- Incorporate final AEROMMA data once available.

References

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