This study presents new results from TROPOMI for NO2/CO emission factors that provide information about combustion efficiency on urban scales. This is an important result for understanding how well these emissions are represented in standard inventories with subsequent impacts for air quality and climate model predictions. I recommend publication after the comments from 2 other referees and some minor issues from me are addressed.

Author Response:

Thank you for your time and comments to improve this paper.

Following the comment of Ref.#1 in addressing the different NO2 and CO lifetimes, the different seasonality in concentrations should also be addressed. For example, is seasonality removed before computing the background CO? Also, in computing emission inventory ratios, are monthly emissions used when matching to data from a particular month, or do you apply annual averages?

Author Response:

To address this point, we switched to monthly emission, using EDGAR v4.3.2 2010 and MACCity 2018. The seasonal correction factor is quantified using EDGAR v4.3.2 2010 since monthly data for EDGAR 2012 is not available (see Fig S18). June to August (JJA) EDGAR 2012 ratio reduces by < 12% for Tehran, Cairo, Riyadh and Mexico City in contrast to annual average inventory derived ratio. However, in JJA MACCity ratio increase by 27.0% Tehran, 10 % for Mexico City, 50 % Cairo and 71 % for Lahore (see Fig 4). The JJA MACCity ratio is close to UBCER and PECER (within 10 %) for all the cities except Los Angeles. EDGAR and MACCity do not agree on the seasonal effect on the emission and comparison of seasonal ratio might result uncertainty in inventory derived ratio. The sentence is added in line 335 to 345.

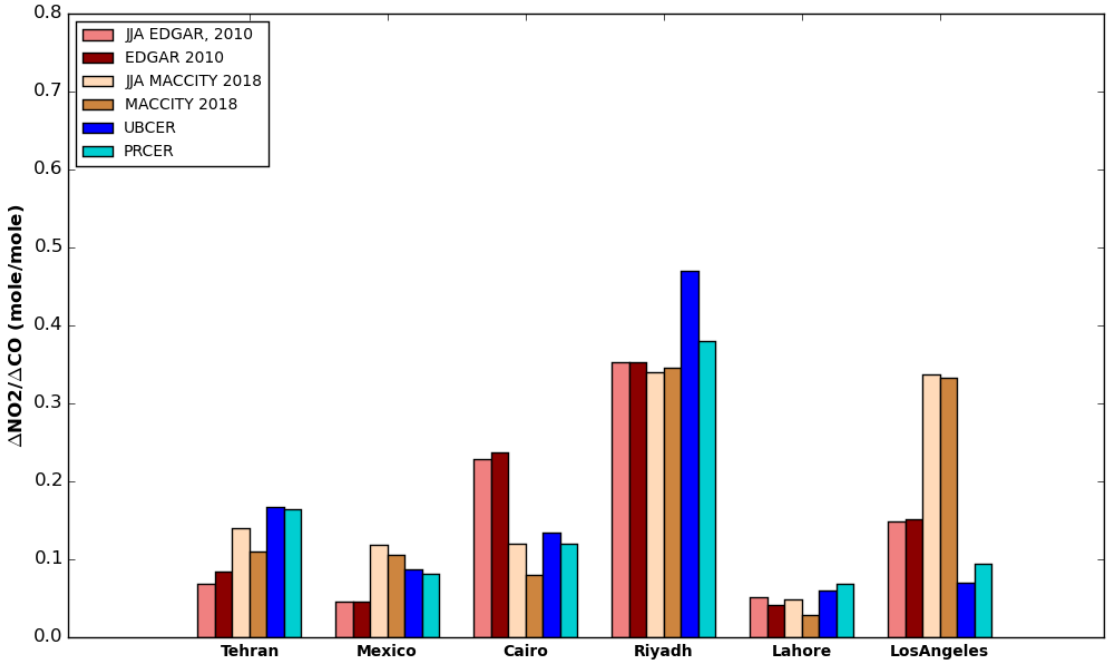

Figure S18. Comparison of EDGAR v4.3.2, 2010 and MACCity 2018 derived emission ratio using annual average emission (dark solid color) and June to August averaged emission (faded color) to the TROPOMI derived emission ratio (blue shades)

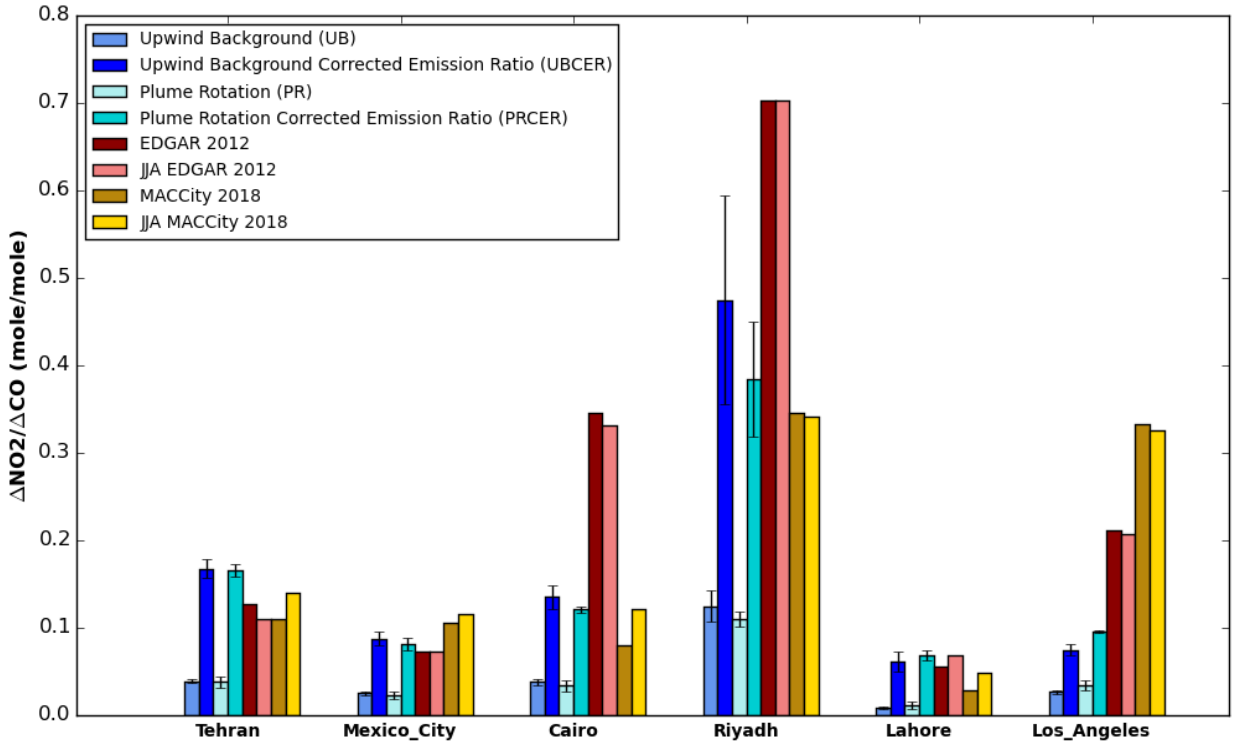

Figure 1. Comparison of TROPOMI-derived $\Delta NO_2/\Delta CO$ enhancement ratios, calculated using different methods shown in blue shades, to corresponding emission ratios from the EDGAR (red shades) and MACCity (yellow shades) emission inventories for six *megacities*. The dark solid shades for emission inventories represent the annual average inventory derived ratio whereas faded shades represents the June to August average inventory derived ratio. Error bars represent 1σ uncertainties calculated using boot strapping (upwind background) and error propagation (plume rotation method). The upwind background corrected emission ratio (UBCER) and Plume rotation corrected emission ratio (PRCER) account for the impact of photochemical NO_2 removal and the averaging kernel.

Abstract. The abstract should state that NO2/CO is a proxy for combustion efficiency since combustion efficiency is a well-defined quantity: CO2/(CO2+CO). This would be better than calling it "burning efficiency", which is confusing since combustion and burning are the same.

Author Response:

In the introduction section Line 74 to 77: "We use the ratio of the TROPOMI retrieved tropospheric column of NO_2 and the total column of CO, which is formally not equivalent to combustion efficiency but can nevertheless serve as a useful proxy (Silva & Arellano, 2017; W. Tang & Arellano, 2017). The reason for this is that NO_x emission increases with combustion temperature, which is high during efficient combustion. In contrast, CO is a product of incomplete combustion, and is produced when combustion efficiency is low (Flagan & Seinfeld, 1988).The combination of these effects makes the NO_2/CO ratio highly sensitive to combustion efficiency" make the things clear about the combustion and burning efficiency.

However I have added the sentence in the abstract to avoid the confusion in line 15 to 17. The sentence is as follows:" NOx (NO+NO2) emission increases during the efficient combustion whereas

incomplete combustion results to higher CO emission. Therefore, NO2/CO is a good proxy for combustion efficiency"

Perhaps the title could be: "Quantifying NO2/CO using TROPOMI to characterize urban combustion"

Author Response:

Thank you for the suggestion but we are not formally quantifying combustion efficiency. However, we deliberately do not use the term 'combustion efficiency'. Therefore we choose to keep the old formulation of the title and explain carefully in the introduction section what we mean by burning efficiency.

Line 57 – should also reference Tang et al., 2019:

-changed as suggested

Line 85 – MOPITT also has a SWIR channel (or near IR) and the multispectral (TIR/NIR) product, with near-surface sensitivity over some land regions, was used in both Silva and Arellano, 2017 and Tang and Arellano, 2017.

-changed as suggested