Analyzing nitrogen oxides to carbon dioxide emission ratios from space: A case study of Matimba Power Station in South Africa

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Highlights

- A new methodology to derive source-specific NO$_x$-to-CO$_2$ emission ratios.
- The method is applied for TROPOMI and OCO-2 satellite observations.
- The mean emission ratio of $(2.6 \pm 0.6) \times 10^{-3}$ is obtained for Matimba Power Station.
- The annual CO$_2$ emissions for Matimba are ~60 kt/d.
- The emission estimates are consistent with existing inventories such as ODIAC.
Background

- CO₂ emissions from point sources can be estimated using different methods, e.g., Gaussian plume model method (Nassar et al., 2016), Cross-sectional flux method (Reuter et al., 2019), see (Varon et al., 2018) for overview
- Satellite-based NOx emission estimation methods are based on statistical analysis
- Can we derive source-specific emission ratios of NOx to CO₂ directly from space-based data?
- We propose an approach based on scaling the observed ratio along the OCO-2 track with simulated data, to obtain the NOx-to-CO₂ emission ratio at the source.

See the paper for details: https://doi.org/10.1016/j.aeaoa.2021.100110
Methodology

1. Select a place of interest and find plumes with both OCO-2 (CO₂) and TROPOMI (NO₂) data
2. Simulate CO₂ and NO₂ plumes using FLEXPART Lagrangian particle dispersion model
3. Calculate the CO₂-to-NO₂ ratio at the cross-section from observations and simulations and derive NOₓ-to-CO₂ emission ratio at the source (see paper for details)
4. Calculate monthly NOₓ emissions using data driven approach (e.g., exponentially-modified Gaussian, Beirle et al., Science, 2011)
5. Use NOₓ-to-CO₂ emission ratio to scale NOₓ emissions to CO₂ emissions
Results

- For Matimba power station in South Africa we found 14 collocated plumes between May 2018 and November 2020
Results

- Annual and monthly NO\textsubscript{x} emission estimated using wind rotation and EMG fitting
- Annual NO\textsubscript{x} emissions are about 40 mol/s (lifetime about 4h)
- Average NO\textsubscript{x}-to-CO\textsubscript{2} ratio is $(2.6 \pm 0.6) \times 10^{-3}$
- CO\textsubscript{2} annual emissions about 60 kt/d
- The emission estimates are consistent with existing inventories such as ODIAC