Review Report

Title: NO_x Emissions Constraints from 1 GEMS NO_2 Retrievals: Inversion Methodology and Air Quality Model Evaluation in Bangkok using ASIA-AQ Multi-Platform Observations

General Comments:

This manuscript investigates daytime hourly Nitrogen Oxides (NO_x) emissions over the Bangkok Metropolitan Region (BMR) using hourly Geostationary Environment Monitoring Spectrometer (GEMS) Nitrogen Dioxide (NO_2) observations. The authors apply the Cross-Sectional Flux (CSF) method via the *ddeq* Python library to derive satellite-based emission estimates, which are then used to update the diurnal NO_x profile in nested WRF-Chem simulations at 20 km and 4 km resolutions. The updated model is evaluated against independent multi-platform measurements from the 2024 ASIA-AQ campaign, including the Thailand Pollution Control Department (PCD) surface monitors, Pandora, the GEOstationary Coastal and Air Pollution Events (GEO-CAPE) Airborne Simulator (GCAS), DC-8, and the High Spectral Resolution Lidar (HSRL)-2 lidar observations.

This work is well-motivated given the growing availability of hourly Geostationary Earth Orbit (GEO)-based composition retrievals and the persistent uncertainty in urban NO_x inventories across Southeast Asia. The effort to constrain the daytime structure of emissions, rather than applying a single scaling factor, is a meaningful methodological advance, and the multi-platform evaluation substantially strengthens confidence in the results.

However, several methodological assumptions, particularly the inconsistency in meteorological fields used across different stages of the analysis, require further clarification. Additionally, while the authors correctly acknowledge a systematic low bias in the GEMS v3 NO2 product, the manuscript would benefit from a clearer discussion of how this bias propagates into the derived emission estimates.

Recommendation: Minor revision

The study is ready for publication after the issues below are addressed.

Specific Comments:

The use of different meteorological fields at different stages of the analysis needs clarification. ERA5 winds are used for the CSF inversion because WRF-Chem winds are biased high, yet the NO_x lifetimes fed into the optimization operator H appear to come from WRF-Chem. The remaining negative biases in WRF-Updated are subsequently attributed to WRF-Chem wind overprediction. The authors should add a short paragraph that clearly separates (a) how the wind bias affects the initial inversion step and (b) how it affects the final model evaluation. It should also be clarified whether the lifetimes used in H are physically consistent with ERA5- or WRF-Chem-based transport, and whether using ERA5-derived lifetimes would materially change the optimized emission profile.

As the authors acknowledge, the remaining negative biases in WRF-Updated are consistent with the known low bias in GEMS v3 NO_2. However, this bias is compounded under high-NO_2 conditions, precisely the conditions characteristic of Bangkok, meaning that emissions derived directly from the uncorrected satellite data are likely biased low. Consequently, the conclusion that EDGAR v5 overestimates NO_x by ~75% should be stated with appropriate caveats, as the true magnitude of overestimation may be smaller once the satellite bias is accounted for. The authors are encouraged to perform a sensitivity test in which the GEMS NO2 columns are scaled by the observed bias ratio derived from Pandora or GCAS comparisons prior to inversion, and to report a bias-corrected emission range alongside the nominal estimate. While this analysis may go somewhat beyond the original scope, it would support your conclusions.

The 24-hour emission scaling approach warrants further justification. Since GEMS constrains emissions only between 08:00 and 14:00 LT, applying a single average scaling factor to unconstrained evening and nighttime hours is a strong assumption, particularly given Bangkok's well-documented bimodal traffic patterns. It is unclear whether this extrapolation is physically reasonable, especially during the evening rush hour. The authors should provide a brief justification or, where possible, compare the implied evening scaling against an independent diurnal reference such as the THAI-KMUTT local inventory profile.

Technical Corrections

Page 1, Line 24: "College Park, postal code, USA" → "College Park, USA"

Page 4, Line 103: "e.g..," → "e.g.,"

Page 4, Line 106: "(Kim et al., 2020; Park et al., 2025).Recent" → "(Kim et al., 2020; Park et al., 2025). Recent"

Page 4, Line 122: "1; Fig 1)(Agarwal et.." → "1; Fig 1) (Agarwal et …"

Page 5, Line 134: Does "1 km^2 resolution" mean the 1 km × 1 km resolution?

Page 8, Line 220: I don't know if it is better to write from "Sentinel5P-TROPOMI" to "Sentinel-5P TROPOMI".

Page 8, Line 225: "LEO observations For our" → "LEO observations. For our".

Page 8, Line 227: "Kuhlmann et al. (2014)" → "Kuhlmann et al. (2024)".

Page 14, Line 376: "where larger correction (e.g., 1.33) where present" → "where larger correction (e.g., 1.33) were present".

Page 25, Line 610: "from that fact that" → "from the fact that".

Page 32, Line 803: "(St. Clair et al., 2019) .We" → "(St. Clair et al., 2019). We".

There is no definition of the HSRL-2.

This is not significant, but authors can use the consistent word:
1. modelled or modeled
2. re-grided or re-gridded