Author response to minor comments from Reviewer#2

Folkert Boersma, 20 October 2025

We have addressed the minor comments by reviewer #2, and adapted the manuscript accordingly, as explained below in blue.

Review

This paper is interesting and should be pubblished.

We thank the referee for this assessment.

I realize on this reading that the analysis does not extend far enough from the peak of the plume to constrain the lifetime. I think this choice of downwind distance is what results in the poor characterization of lifetimes in this paper compared to others. A brief mention that other analyses try to follow the peak of the plume more than 1 e-fold down wind would be helpful in placing this paper in context of the analyses that have tried to get at NOx lifetime.

Our method does actually constrain the lifetime above the city. This is clearly demonstrated by the sensitivity study described in Section 3 which shows that the Bayesian inversion reproduces the domain-average lifetime in the MicroHH model - to within 35 minutes. We agree that including the decaying plume outside of the city in the study domain could possibly lead to stronger numerical constraints on the NOx-lifetime, but deliberately refrain from doing so, because of the strong differences in photochemistry between the urban area and the downwind plume, as shown in Figure 3. We now include the following explanation in section 3.2 that mentions this issue:

"Some studies estimate NO\x lifetimes by analyzing the exponential decay of the NO2 plume downwind of a city (e.g. Beirle et al. [2011], de Foy et al. [2014], Liu et al. [2022]). While this e-folding distance approach can provide additional constraints on the NOx lifetime compared to our method, which relies solely on the enhancement of NO2 over the city, it does not account for variations in photochemistry between the urban area and the downwind plume (as illustrated in Figure 3)."

Also, as a minor note, I expect formation of RONO2 as an NOx-sink—at a level of ~15%. Probably doesn't affect the results of this paper since the lifetime is interpreted as a regularization parameter and not chemically.

We agree that organic nitrate ($RONO_2$) formation can represent a non-negligible NO_x sink, typically on the order of 10–20%. Our approach does not explicitly separate different chemical loss pathways, but fits an effective NO_x lifetime (mentioned in sections 2 and 4.1.2) that implicitly includes all loss processes (e.g., HNO_3 and $RONO_2$ formation). We therefore expect that $RONO_2$ formation contributes to the effective loss rate retrieved, without affecting the conclusions of this study. We updated section 2 to

reflect this better, by mentioning that the main loss process is oxidation to HNO3, “with some loss to organic nitrates (RONO2)