

Interactive comment on “High resolution vertical distributions of NO₃ and N₂O₅ through the nocturnal boundary layer” by S. S. Brown et al.

S. S. Brown et al.

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We thank both reviewers for their comments to the manuscript. Listed below are our responses to their comments and the corresponding changes made to the revised manuscript.

Referee #1

1. Fate of the NO_x that was lost (rather than stored aloft): The fate of the NO_x lost aloft is unclear, although two likely possibilities would be HNO₃ formation followed by depositional loss after sunrise, or organic nitrate formation. The reviewer's point about the possible importance of mixing is well taken; however, as we had stated in the original version of the manuscript, we had explicitly neglected this effect in making this very rough calculation. Because it would be difficult to accurately account for mixing

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based on the available data, we have made no attempt to do so. The rough estimate of NO_x storage vs. loss was intended to contrast the upper layers from the lower layers in a qualitative manner. A sentence has been added to the revised manuscript to clarify this point.

2. NO_x surface emissions: The reviewer makes a good comment regarding the likely relative importance of different NO₃ and N₂O₅ sinks near the surface during this study. Periodic sampling of air masses containing large amounts of NO_x from nearby sources is more likely to explain the observations than are soil NO emissions. Although this point had already been made in the discussion, it deserves better emphasis. A sentence has been added to the revised manuscript to make this point more explicit. It is worth noting, however, that the other potential sinks (NO₃ reaction with surface emitted VOC, gradients in N₂O₅ hydrolysis) remain potential contributors to the observed gradients. Additional measurements with more complete ancillary data may allow us to differentiate between these mechanisms in the future.

Referee #2

1. Duration of the study: We would indeed like to have had more than a single night's data, so we share the reviewer's sentiment on this point. Although it may seem that the logistical cost of the set up would make it desirable to have measured for several nights, the opposite was in fact true; The logistics were relatively simple, but we felt that the data from a more complete set of measurements would be of more value. Hence the limited data set. A more detailed study is currently being planned.

2. Suggested word changes: All suggested changes have been adopted. ".. can be influenced by a number of factors." has been replaced by "Ě may vary" ; ".. NO_x oxidizes Ě" has been replaced by "Ě NO_x is oxidized Ě" ; "average gradient" has been replaced with "average difference" to describe the relative humidity variation with height.

3. Reservoir behavior of N₂O₅: The reviewer is correct; the Brown et al. (2006) reference was not the first observation of N₂O₅ as an NO_x reservoir, although it is,

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to our knowledge, relatively novel in its discussion of N₂O₅ as an O₃ reservoir. An earlier reference from Perner et al. (1985) has been added on page 9433 regarding NO_x reservoir behavior of N₂O₅.

4. The Friedeberg reference can be found as von Friedeberg (under "v" not "F" in the reference list). Hopefully this is not in error!

5. The uncertainty in the O₃ monitor is the combination of the slope uncertainty (2%) and the offset uncertainty (2 ppbv). It can be taken as the larger of the two.

6. Use of potential temperature: This is a better measure of static stability than temperature alone. A comment to this effect has been added to the revised manuscript.

7. Timings between the text and Figures (4), 6, 7 and 8. We thank the reviewer for catching this error! Due to a profile numbering error, the times of the profiles in Figure 4, 6, 7 and 8 had all been shifted by approximately one hour. The error has now been corrected, and times throughout the manuscript have been checked for consistency. The error did not affect any of the conclusions of the manuscript.

8. Figure 2: The NO₃ mixing ratio has been scaled by a factor of 5 to make it more visible and has been labeled accordingly.

9. Time of sunset at 300 m: A very rough, two dimensional estimate suggests about 2 minutes difference between sunset at the top of the 300 m tower and the surface. The caption to figure 2 has been changed to indicate that the marked time is for a solar zenith angle of 90 degrees at the surface.

10. See comment #7. N₂O₅ was not, in fact, present in large concentrations prior to sunset. The profiles prior to sunset in figure 4 show concentrations of N₂O₅ consistent with the period around dusk (~10 pptv on this night).

11. Difference vs. similarity in NO₃ and N₂O₅ profiles early and later in the night: The reviewer makes a good observation. Profiles taken later in the night, when the NO_x levels were lower, also tended to have more uniformly distributed NO₂ (as inferred

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from the N_2O_5 to NO_3 ratios). These two phenomena (lower concentration and more uniform vertical distribution) are likely related.

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