**Atmospheric
Measurement
Techniques
Discussions**

Interactive comment on "The development of a nitrogen dioxide sonde" *by* W. W. Sluis et al.

Anonymous Referee #1

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General Comments:

The manuscript "The development of a nitrogen dioxide sonde" by Sluis et al. describes an instrument for nitrogen dioxide (NO_2) profile measurements in the troposphere, with the mixing ratio range between 1 and 100 ppb. NO_2 profile measurements are rare. Availability of an inexpensive and accurate NO_2 sonde could result in data collection of great importance to satellite and air quality model validation. The manuscript, in general, is well written; however, a number of points need further clarification. The main confusion arises from characterization and correction of the scale factor to calculate NO_2 number density. Below is a list of specific comments and questions.

Specific Comments and Questions:

Line 10 (Page 2809): How was the air flow rate chosen? Since the reaction takes place at the gas-liquid inter-phase, some dependence of signal on the air flow rate is expected.

Line 15 (Page 2809): What is the mechanism of the luminol solution recycling? Is it dilution with the more basic luminol solution?

Line 6 (Page 2815): Please specify under which conditions the pH measurements shown in Fig 5 were taken. If they were recorded at surface pressure, pumping ambient air, the acidification rate is probably the largest possible due to maximum CO_2 partial pressure compared to the flight conditions (decreasing pressure with height). The acidification rate also will depend on the sonde ascend velocity (the higher the vertical velocity the shorter the residence time at the lower altitudes with large CO_2 partial pressures). If pH correction is important, you should consider measuring it during the flight.

Line 20 (Page 2815): Why is there a temperature dependent offset between the "seeing" and "blind" photodiodes? If they are "identical" and there is no light emission due to chemilunimescence reaction, and no light leak, the "dark" signal of both arrays should exhibit similar temperature dependence.

Line 3-8 (Page 2816): You point out that the scaling factor, "f", depends on luminol solution properties and the amplifiers. I would assume that the air pump flow rate and changes in its efficiency during the flight would impact "f". Have you simulated pressure decrease, characteristic of the sonde atmospheric ascent, in the RIVM calibration facility? Please specify under which conditions the measurements shown in Fig 7 were taken.

Line 10-14 (Page 2816): You mention three temperatures: air pump temperature, luminol solution temperature, and box temperature. In your response to Dr. Ching-Ho Lin (comment 3), you point out that "For the sondes we make today, we measure pump and solution temperature to remove this small uncertainty." It might be useful to show an ex-

ample of the in-flight air pump and luminol solution temperature measurements, while discussing temperature correction. The reported air box temperature range is 20C – 40C. This might result in up to 40% change in signal, depending on the temperature change pattern. What is the heat source in the system? Would applying insulation with higher thermo conductivity help with this problem?

Line 24 (Page 2816): Do the sonde and chemiluminescence analyzer measure ambient air or CO2 free air with a known NO2 concentration during prelaunch calibration?

Line 29 (Page 2816): Signal correction as a function of time due to pH changes measured at surface pressures might not be representative of the flight conditions.

Line 12-13 (Page 2817): How is the scale factor estimated in the absence of preflight calibration?

How repeatable are the sondes (one to another)?

What is the total estimated error of the NO2 measurements?

Technical corrections:

Line 8 (Page 2806): remove "+ -" before 700g. You might also want to replace 700 g with 0.700 kg for consistency.

Line 14 (Page 2806): Spell out in full RIVM.

Line 5 (Page 2807): Spell out in full ACCENT-AT2.

Line 11 (Page 2807): Pluralize "converter".

Line 13 (Page 2807): Place a comma after "for example".

Line 17 (Page 2808): Spell out in full EDTA.

Line 1 (Page 2809): Raise cm to 3rd power.

Line 8 (Page 2809): Raise mm to 3rd power.

Line 8, 14 and 15 (Page 2810): Replace "in the order of" with "on the order of".

Line 16 (Page 2810): Spell out in full "RC".

Line 18 (Page 2810) Raise mm to 3rd power.

Line 2 (Page 2814): Na_2SO_3 belongs to both protective and reaction groups.

Line 8 (Page 2814): Please rephrase this sentence. It reads as if you knew the standard concentrations before doing the experiment.

Line 9 (Page 2814): Insert concentrations into: "This is done by varying the concentration of one component over a range while holding "concentrations" of other compounds constant. . ."

Line 12 (Page 2814). The molar concentration of the chemicals is expressed in M (mol/l) units.

Line 15 (Page 2818). Capitalize "a": Fig. 10(A)

Figure 1: It might be better to take a picture of the sonde where no other objects are in the field of view.

Figure 2: Be consistent in referring to "seeing" and "blind" photodiodes. Throughout the text, these terms are sometimes in quotes and sometimes without quotes. Replace "site" with "side" and "aluminium" with "aluminum" in: "An aluminium mirror is placed on the opposite site to reflect the emitted photons back to the seeing photodiodes". Could you please explain the purpose of the middle arrow pointing up from the luminol recirculation vessel?

Figure 3: I am not sure this figure adds new information that cannot be conveyed using Fig 2 and words.

Figure 4: Insert brackets around A and B: "(A) and (B) show . . ." Also, please add the signal standard deviation (stdev) for the 15 min signal averages. Without stdev it is not

obvious what the optimal range is. Why was the 4th order polynomial chosen?

Figure 5: Please specify under which conditions the pH measurements shown in Fig 5 were taken: T, P, air flow rate, luminol solution, etc.

Figure 9: It might be useful to show the NO2 mixing ratios measured by the sonde on the y-axis, while the photolytic analyzer data are shown on the x-axis.

Figure 10: I would recommend changing the number density (x-axis) with the mixing ratio for consistency with the rest of the text.

Table 1. Replace "aquatic" with "aqueous".

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