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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Biogenic emissions of NO_x from recently wetted soils over West Africa observed during the AMMA 2006 campaign" *by* D. J. Stewart et al.

Anonymous Referee #1

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This paper presents aircraft NOx observations obtained over West Africa during July and August 2006, as part of the AMMA campaign. These observations show a pronounced increase in NOx following rain events, consistent with biogenic soil NOx emissions. The measurements are very interesting and the relationship between observed NOx concentrations and land surface temperature anomaly (a proxy for soil moisture) is striking in the three case studies. Beyond that, I find the interpretation of these measurements in terms of flux measurements and their extrapolation to be flawed. I suggest significant revisions to this paper.

Specific comments

1. Flux calculation: time-dependent vs. steady-state

The authors do not justify the way that they have set up their flux calculation (section 3.4). They assume that at sunrise NOx concentrations are the background concentrations measured over dry soil. Then, between sunrise and the time of observations (~8-10 hours later), constant soil NOx emissions are applied. Are there no biogenic emissions at night? The observations were typically 18 hours-3 days after a rain event, so why assume that soil NOx production only occurred since sunrise? Why assume that the initial NOx concentrations at sunrise are at the values observed over dry soil? The dry soil measurements are also taken in the afternoon and that NOx is also subject the same loss processes as the NOx over wet soils.

Why not, more simply, assume that the NOx concentrations are at steady-state, such that F = H L Cwet. This eliminates the need to assume a time over which soil NOx emissions occur and also does not require any assumptions about background NOx concentrations. In practice this gives results that are very similar to the ones obtained with equation (3), especially for short lifetimes (for OH = 5e6 and 10e6 molec/cm3, the NOx lifetime is 4 and 2 hours, respectively using the values given by the authors). For OH = 0 and 1e6 molec/cm3 the NOx lifetimes are much longer: 9 days and 21 hours. Actually, a 9 day lifetime for NOx is unrealistically long and there is no reason to believe that OH concentrations would be zero and that there would be no chemical loss. I suggest eliminating the case where OH =0 from the paper.

Also, a more detailed discussion of the OH observations on board the aircraft would be useful. What range of values were observed under what conditions?

2. Flux calculation: dry versus wet

It appears that the authors assume that soils that have not been wetted recently do not emit NOx. Field measurements (for example summarized by Davidson et al., 1997) show that semi-arid soils emit little NOx during the dry season, but then after an initial pulsing following the first rains of the season, soil NOx emissions are lower but still

ACPD

7, S7939–S7942, 2007

significant during the remaining of the wet season. Indeed, Stewart et al. measure significant background NOx concentrations over dry regions (outside the wet regions), with values ranging from 210-400 ppt. If there are no other significant sources in this region (biomass burning or fossil fuel combustion) as suggested by low VOC and CO concentrations, then significant soil NOx emissions would be needed to maintain these high NOx concentrations, especially given the deeper boundary layer height.

In fact, assuming steady-state and the same OH levels as the authors, I find that the soil NOx emissions needed to maintain these observed NOx levels are about 25-60% lower than over wet soils. The factor of 3 difference in NOx concentrations is counterbalanced by the factor of 2 difference in boundary layer height. These fluxes cannot be neglected.

3. Significance of calculated flux (section 3)

The authors scale up their flux over wet patches to a 2.3 million km2 over the Sahel. They assume that at any given time 11% of that region has seen recent rain and apply the following formula:

Total N = F x A x 0.11 x t

For a 2-month period between July and August they find that these regions account for 0.01-0.05 TgN. They assume that the regions outside these recently wetted areas do not emit biogenic NOx. Again, this is not realistic (see section 2 above).

Using flux values inferred from NOx observations over dryer areas, I calculate that these dryer regions emit significant levels of NOx. Applying the following formula (assuming that these fluxes occur over the remaining 89% of the region):

Total N (dry) = Fdry x A x 0.89 x t

the resulting NOx emissions range from 0.001 (OH=0) to 0.3 TgN!

Adding the two together, NOx emission over the Sahel range of 0.01 to 0.36 TgN. Compared to the top-down satellite estimates in Jaegle et al (1994) of 0.19 TgN, these

ACPD

7, S7939–S7942, 2007

values are not too different, and even exceed them by a factor of almost 2 at the high end of the OH concentrations assumed.

4. Comparison to the Delon et al. paper in ACPD.

The authors briefly mention the Delon et al. paper which applies a mesoscale model and a neural network approach to modeling soil NOx emissions. Given that there is significant overlap between the 2 papers, it would be useful to see more of a discussion comparing the results of the Stewart et al. paper to the Delon et al. paper. For example how do the model calculated soil NOx emissions in Delon et al. compare to the simpler upscaling approach presented in the present paper?

5. Other comments

+ page 16257, line 2. What is the detection limit and accuracy of the TECO instrument? The values are given for the UEA Noxy instrument but not for TECO.

+ Given that the main argument against an anthropogenic origin for NOx is the lack of correlation with CO, I suggest that the authors show the CO measurements on Figure 3.

In summary, the measurements are very interesting and provide new information on biogenic soil NOx emissions over regional scales. I commend the authors for attempting a simple approach in extrapolating their results to a larger region, but find their efforts flawed.

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7, S7939–S7942, 2007