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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Lightning activity in Brazilian thunderstorms during TROCCINOX: implications for NO_x production" *by* H. Huntrieser et al.

H. Huntrieser et al.

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We thank Reviewer #1 for the helpful comments.

-Page 14821, line 22: In section 6 it is RINDATs VLF components that are grouped into flashes, not LINETs. The paragraph implies that this is done for LINETs strokes. Please clarify this.

- Yes it is correct that in Sect. 6 RINDATs VLF components are shown, however the number given in this section was calculated for LINET. Sentence changed to: However, a small set of strokes were combined manually into flash "components" (nearby strokes within 1 s), which indicate that LINET locates few VLF strokes per flash components, on average 3 and up to 9 (not shown).

-Page 14821, lines 5-10: Could the authors please quantify the LINETs detection efficiency for both its central detection area as well as its periphery?

- Here probably Page 14822, lines 5-10 are meant: Sentence changed to: The detection efficiency, stroke-current dependent, is highest in the LINET centre area (2°x2°) with >90% and decreases rapidly down to 30% towards the periphery (Betz et al., 2004, 2007a-b, Schmidt et al., 2007).

-On page 14837, when computing PLNOx for the storms on 4 February, the authors only consider LINET strokes with peak currents >10kA. The author state later in the manuscript (page 14849) that these weaker strokes are responsible for producing "only" 50% of the storms LNOx. While the LNOx production in these storms is heavily weighted towards those strokes with high peak currents (10% of the strokes with peak currents >10kA are responsible for 50% of the storms LNOx production), the authors are discarding a statistically significant portion of the stroke population and the non-negligible portion of the NOx that they strokes produce. This could have as a consequence an underestimation of both the tropical storms LNOx production and the global NOx budget. A note of caution on this fact would be welcome.

- As already mentioned on this page, only LINET strokes with peak currents >=10 kA were considered for the reasons mentioned in Sect. 4.1 (for an adequate comparison between the 4 and 18 February thunderstorms). For the estimate of the global NOx budget (here based on LIS flashes) this restriction to LINET strokes with peak currents >=10 kA has no major influence, since the amount of the LNOx mass flux in the thunderstorm was only in a first step scaled to the number of LINET strokes with peak currents >=10 kA. In the next step these LINET strokes were with peak currents >=10 kA were scaled to the number of LIS flashes, as described in Sect. 4.5. Therefore, these LINET strokes are just used in an intermediate step to connect the LNOx mass flux observed in each storm to the number of LIS flashes. In Sect. 7 (Summary and conclusions) the sentence on page 14856, lines 11-13, was changed to: Also the attribution of the set of observed stroke events (only strokes with peak currents >=10 kA

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considered) to the LNOx increase is very uncertain.

-On page 14485, the authors mention that those strokes from LINET data classified as uncertain are defined as CG strokes (without ruling out the possibility of them being IC strokes). Given that IC strokes, both positive and negative, amount, in the storm under study, to 57% or more of the total flashes, the above assumption may lead to significant biases in the results, all the more given that the differences in peak currents, including the polarity, between the different types of flashes are significant. Please include a sentence to mention this.

- Here probably Page 14845 is meant. A new sentence (line 5) was added: This uncertainty may lead to significant biases in the results presented below in Table 4a-b.

-Page 14821, line 22, Please substitute "..6a.." with "6 a"

- In this sentence Sect. 6 was cut as stated above in the first answer.

-Page 14821, line 12 "allows for comparison.."

- Corrected.

-Page 14821, line 23 should read: "..manually into flash.."

- Corrected.

-Page 14821, line 22: "In Sect. 6 a small set of strokes were combined manually to flash "components", which indicate that LINET locates few VLF strokes per flash component (on average 3 and up to 9).": The sentence is not clear; how does the fact that strokes were manually combined implies that LINET locates few strokes per flash?

- Sentence changed to: However, a small set of strokes were combined manually into flash "components" (nearby strokes within 1 s), which indicate that LINET locates few VLF strokes per flash components, on average 3 and up to 9 (not shown).

-Page 14822, lines 5-7; What is LINETs detection efficiency in the centre area? State

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accuracy in same terms as RINDAT to compare the 2 networks.

- Sentence changed to: The detection efficiency, stroke-current dependent, is highest in the LINET centre area (2°x2°) with >90% and decreases rapidly down to 30% towards the periphery (Betz et al., 2004, 2007a-b, Schmidt et al., 2007).

-Page 14822, line 11 replace "on board" with "onboard" or "on-board"

- Corrected.

-Page 14822, line 15 "...the duration of a measurement" is not right; What this means is that sensor can view any one area in its footprint for a period of 90 secs.

- Sentence changed to: The sensor can view any area on its footprint for a period of 90 s which is long enough to estimate the flashing rate of most thunderstorms in the field of view during the passage (see http://thunder.msfc.nasa.gov/lis/).

-Page 14822, line 23 "on 4 February"

- Corrected.

-Page 14822, lines 26; RINDATs detection efficiency appears to be quite good (80-90% for peak currents above 10ka and a location accuracy of 0.5-2km); if larger than LINETs, one could ask, why not use RINDAT as the main lightning detection network?

- As stated in Sect. 2.2 the LINET system has several advantages: peak currents as low as 1-2 kA can be detected in the centre area and IC and CG flashes can be distinguished. However, these advantages are less important when the 4 and 18 February storms are compared, since the 18 February storm occurred along the LINET periphery where only larger peak currents can be detected (>=6 kA) and IC and CG flashes cannot be distinguished.

-Page 14823, lines 12-14; what is this assumption based on?

- Sentences added and changed: Past cloud model simulations by Pickering et al.

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(1998), showing the vertical distribution of released LNOx in tropical continental thunderstorms, indicate released LNOx mainly between 5 and 13 km and an increase with altitude. However, because of the low resolution of the ECMWF wind fields (0.5° horizontally) used as input for FLEXPART (HH07), the distribution of lightning sources is assumed to be uniform in the vertical in the present study.

-Page 14824, line 9-11; I most definitely cannot discern an azimuth bias on RINDATs stroke distribution plot....

- Sentence changed to: Overall, a general agreement was found, but with a slight shift of RINDAT strokes to the west compared with LINET strokes, especially in Fig. 1b.

-Page 14826, line 15, Please substitute "altitudes" with "altitude".

- Corrected.

-Page 14827, line 27, Please substitute "main" with "prevailing".

- Corrected.

-Page 14828, line 27, Please substitute "downstream" with "downwind".

- Here probably line 5 is meant: Corrected.

-Page 14829, lines 24 and 27, should read "left hand side transects" and "right hand side anvil transect", respectively.

- Corrected.

-Page 14830, line 19: Do you mean to say that the storm developed in one hour? If not, please clarify.

- Sentence changed to: For the thunderstorms of 4 February, no FLEXPART simulations were performed since the storms just developed about one hour before the penetrations and this time was considered too short for realistic simulations.

-Page 14834, line 24: Please substitute "further" with "farther".

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- Corrected.

-Page 14838, lines 14 and 15: Please cite references for recent LNOx production estimates.

- Several references were already cited in the introduction. Sentence (line 11-12) changed to: These values are close to previous best estimates for mid-latitude thunderstorms over Europe, 3-4 Tg a-1 (Huntrieser et al., 1998, 2002), see also introduction.

-Page 14846, line 9: Please delete "The".

- Corrected.

-Page 14851, line 3: Please delete "respectively"

- Here probably line 23 is meant: Corrected.

Further changes by the author:

- The following references were added: Pickering et al., 1998 (for reasons mentioned above); Schmidt et al., 2007 (for reasons mentioned above); Betz et al., 2007b (for reasons mentioned above).

- The authors found additional material supporting their hypothesis in Sect. 6 (Discussion). The following references were added to page 14850, lines 21-26: Carey et al., 2005; Ray et al., 1987; Steiger et al., 2007a-b. Furthermore, the text of this paragraph was complemented: A lateral displacement of upper level charge on the convective scale (˜10 km) because of vertical wind shear (0-6 km) was first suggested by Pierce (1955), Brook et al. (1982), Ray et al. (1987), and Hill (1988) (known as "tilted dipole mechanism"). Later, observations by Engholm et al. (1990) of MCS confirmed a tilted deformation of the convective charge centre by the vertical wind shear. Contrarily, Rutledge and MacGorman (1988) first suggested that the origin of charge for positive ground flashes in the trailing-stratiform region of MCSs was the rearward advection of positive charge on large aggregates of ice particles from the MCS convective charge

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centre (leading line) by the mesoscale storm-relative winds (now known as "charge advection mechanism"). More recently, these mechanisms have also been discussed by Gilmore and Wicker (2002), Carey et al. (2005), Carey and Buffalo (2007) and Steiger et al. (2007a,b). However, the VHF lightning observations by Carey et al. (2005) clearly indicate that the "tilted dipole mechanism" and the "charge advection mechanism" are two different mechanism on different scales (convective and mesoscale) that should be considered separately.

- Fig. 17c was missing in the ACPD version: Figure added.

- A new schematic figure (Fig. 18) was added (Sect. 6, page 14850, line 14), showing the horizontal separation of charged regions by the enhanced vertical wind shear, to support the hypothesis described in this paragraph.

- The previous Fig. 18 was now changed to Fig. 19.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 14813, 2007.