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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Lightning-produced NO_x over Brazil during TROCCINOX: Airborne measurements in tropical and subtropical thunderstorms and the importance of mesoscale convective systems" *by* H. Huntrieser et al.

H. Huntrieser et al.

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- We thank Reviewer #1 for the helpful comments.

General Comments: My only strong criticism of this paper is the small size of the figures, many of which are difficult to interpret, or contain text so small that it is illegible. The smallness of the figures may be due to the formatting of the paper by ACPD, since I often make this complaint about ACPD papers. Regardless, all but Figures 6, 8, 9, 10, 13 and 14 need to be increased in size by at least 50%.

- In general the figures will be increased by at least 1/3 in the ACP-version. The follow-

ing figures were additional improved (see also comments on figures on the last page):

Fig. 1: x-axis stretched and legend increased.

Fig. 2: latitude and longitude labels and vanes increased.

Fig. 4-5: labels on the right increased.

Fig. 7: figures a-b set below each other and increased.

Fig. 12: figures a-b set below each other and increased.

Fig. 15: figures a-b set below each other and increased.

Fig. 16: figures a-b set below each other and increased.

In the discussion of Figure 18 it is not clear which air masses are “Pacific” or “Amazon.” Are these just air masses from the Feb 18 flight, or are they combinations of data from several flights? It would be helpful to circle these data points in Figure 18.

- As described in the text, both of these air mass types are characterised by low O3 mixing ratios ˜20-40 nmol mol-1. Pacific air masses, also characterised by low CO mixing ratios (˜40-60 nmol mol-1), were observed during sequences of all three selected flights (see colour dots in Fig. 18a). Air masses from the Amazon basin, also characterised by elevated CO mixing ratios, were not observed on 28 February 2004. The text in Sect. 5 describing the connection between the selected flights, the colour dots and the correlations was improved as described below. The data points in Fig. 18 were not circled due to too much confusion (no clear transition between these and background air masses). The reader is referred to the text in Sect. 5 for the detailed interpretation of the figures.

- The following sentences were added (page 2583, line 23): “CO, O3, and NOy data from the flights on 28 February 2004 (grey dots), 7 March 2004 (yellow dots) and 18 February 2005 (b-flight) (white dots) were selected for Figure 18a and only data from the latter two flights for Figure 18b-c. The different air mass origins are labelled

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(branches in correlation plot). ”

- The following sentence (page 2583, line 26-28, page 2584, line 1-4) was changed to: “As discussed before, both of these air mass types were characterized by low O3 mixing ratios of 20 to 40 nmol mol-1, see Fig. 18a. In the Pacific air mass, O3 and CO was positively correlated and CO mixing ratios were low in the range of 40-60 nmol mol-1 (pronounced on 28 February 2004 and slightly visible on 7 March 2004 and 18 February 2005). In comparison, the air mass originating from the Amazon basin contained elevated CO in the range of 80-110 nmol mol-1, and O3 and CO was negatively correlated (pronounced in the UT on 18 February 2005 and in the BL on 7 March 2004).”

- The following sentence (page 2584, line 5-12) was changed to: “During ascent and descent in the BL, a positive O3-CO correlation, probably due to photochemical O3 production, was observed in some cases in subtropical air masses (28 February 2004 and 18 February 2005), with O3 and CO mixing ratios reaching up to 50 and 140 nmol mol-1, respectively (Fig. 18a).”

And on page 2585, lines 21-23, I don’t see the positive or negative correlations that are discussed.

- Sentence changed to: “In the MCS outflow on the same day, labelled as MCS in Fig. 18b, a slightly positive (negative) NOy-CO correlation at the lower (upper) boundary of the yellow dots was observed, indicating the mixture of a polluted air mass (positive correlation) with an air mass from the UTLS region (negative correlation).”

Specific Comments: Abstract, line 9 What do the authors mean by “proper” wind direction?

- Proper wind direction deleted and importance of Bolivian High added. Sentence changed to: “Tropical air masses were discriminated from subtropical ones according to the higher equivalent potential temperature in the lower and mid troposphere, the

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higher CO mixing ratio in the mid troposphere, and the lower wind velocity in the upper troposphere within the Bolivian High (north of the subtropical jet stream)."

Page 2563 line 1: Drop the first word of the sentence, "The" line 10: drop "at least"

- Corrected.

Page 2564 line 5: change access to assess

- Corrected.

Page 2565 lines1-2: would sound better as "DLR Falcon research aircraft"

- Corrected.

Page 2569 lines 14-15, would sound better as: " The convective systems occur on a wide range of temporal and spatial scales."

- Corrected.

Page 2571 line 14: Do you mean to say "connected to low northerly and easterly wind velocities" ?

- Sentence changed to (in accordance with abstract): "3) circulation within the Bolivian High connected (in general) to low wind velocities in the UT (north of the subtropical jet stream)"

Was FLEXPART also used in the air mass classification?

- Yes (however not shown in detail for every case), new sentences added: "In addition, FLEXPART backward simulations were used (not shown in detail) to trace back the air masses to confirm the tropical (circulation within the Bolivian High) or subtropical (Pacific) air mass origin (see FLEXPART example in Sect. 3.3.4 and http://zardoz.nilu.no/~andreas/TROCCINOX/). However, for thunderstorms located close to the SACZ the clear air mass determination was sometimes difficult."

Page 2572 line 13: I disagree that the CO profile has a pronounced C-shape. To me

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it looks like a very flat C. The only way it could be pronounced is if the x-axis were stretched by a factor of 2 or 3.

- Changed to “The flat C-shape..” In addition the x-axis has been stretched.

line 23: How does this paper differ from Mari et al?

- The paper by Mari et al. reports on model simulations with Meso-NH carried out for the TROCCINOX cases 3-4 March 2004 (cases not discussed in detail in the present paper by Huntrieser et al.) and compare these to airborne trace gas measurements. Mari et al. have implemented a lightning NOx source in the deep convection scheme of the Meso-NH mesoscale model following a mass-flux formalism coherent with the transport and scavenging of gases within the convective scheme.

Page 2575 line 4: change “area” to “NOx plume”

- Changed to “LNOx plume”.

Page 2577 line 24: I don’t understand what is meant by “grouped to flashes”

- Sentence changed to: “One or more adjacent lightning events in the same 2ms time frame can be bunched together to form a group. A flash consists of one or more groups sufficiently close in time and space (not shown here).”

Page 2578 line 12: Here you say that the trajectories ascend as they circulate within the high, but the general understanding of circulation within a high would suggest the trajectories would descend. Why the discrepancy?

- The Bolivian High (connected to divergence) is located in the upper troposphere. Below this high, a heat low is located at the surface (connected to low-level convergence in the Amazon basin). Sentence changed to: “The air mass was transported to the north and then to the west, slightly ascending to 150-200 hPa within the Intertropical Convergence Zone (ITCZ), and circulated further westwards driven by the Bolivian High to a region between 20°S to 5°S and 80°W to 65°W (Fig. 13).”

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line 24: change usually to usual

- Corrected.

Page 2579 line 6-7: The parentheses are not closed, making this sentence confusing.

- Sentence changed to: The horizontal wind velocity was almost constant with altitude and weak, which seems to be typical for air masses within the Bolivian High, see Fig. 5c and Fig. 14 (here data from a further flight, 5 February 2004, was also included).

line 27: the use of seconds past midnight is not helpful. Only UTC should be used and figure 6 should be changed accordingly.

- Not changed. For the present paper seconds past midnight might be less helpful, however in the forthcoming paper the elapsed UTC time since midnight (in seconds) is used in a table where all penetrations are listed. This unit is frequently used for the presentation of time series of airborne measurements in the literature. The advantage is that the anvil penetrations listed in the table can easily be identified in the figures.

Page 2582 line 1: Would be more clear as: “The values represent averages of the lowest 100 m layer of the atmosphere at take-off or landing”

- Corrected.

line 16: drop “the” at the beginning of the line

- Corrected.

Page 2583 line 21: change to “trace gas correlations” line 25: would be clearer as “above the Pacific Ocean”

- Both corrected.

Page 2586 line 8: change to “in great detail”

- Corrected.

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lines8-9: change to “This paper presents”

- Corrected.

Figure 1. Stretch the x-axis to pull the data lines apart

- X-axis stretched.

Figure 2: the text on the plot is illegible

- Figure enlarged and latitude and longitude labels increased.

Figure 2 & 3. Label the figure with S or T to distinguish tropical from subtropical events.

- S and T added to Fig. 3 where the position of the SACZ is indicated and the flight track from Fig. 2 is included.

Figure 3: what do the circles (or ellipses) represent?

- Probably Fig. 2 is meant. See figure legend: “The areas with anvil penetrations are marked with circles and labelled (see also Fig. 6).”

Figure 4. locations of the radars are not visible. Please overlay the flight tracks. Figure 5. Figure 5b is the same as Figure 4b. The locations of the radars are not visible. Please overlay the flight tracks.

- The locations of the radars were cut (not important for the present paper). The flight tracks were superimposed. Fig. 5b was replaced by the right figure.

Figure 6 Change x-axis to UTC and remove the red numbers and roman numerals from the x-axis as they are not used in the text.

- The x-axis was not changed (see arguments above) and the red numbers and roman numerals were not removed since these single penetrations (also marked in Fig. 2) are discussed in more detail in the forthcoming TROCCINOX-paper in preparation by Huntrieser et al., as stated in the present paper (too avoid repetition of these figures).

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Figure 7 Indicate the position of the MCS with arrows.

- MCS marked with arrows.

- In addition, further references were added to the reference list and cited in the text:

Andreae, M. O., Anderson, B. E., Blake, D. R., Bradshaw, J. D., Collins, J. E., Gregory, G. L., Sachse, G. W., and Shipham, M. C.: Influence of plumes from biomass burning on atmospheric chemistry over the equatorial and tropical South Atlantic during CITE 3, J. Geophys. Res., 99, 12793-12808, 1994.

Salio, P., Nicolini, M., and Zipser E. J.: Mesoscale convective systems over southeastern South America and their relationship with the South American low-level jet, Mon. Wea. Rev., 135, 1290-1309, 2007.

Sato, M., and Fukunishi, H: Global sprite occurrence locations and rates derived from triangulation of transient Schumann resonance events, Geophys. Res. Lett., 30, 1859, doi:10.1029/2003GL017291, 2003.

Sauvage, B., Martin, R. V., van Donkelaar, A., Liu, X., Chance, K., Jaegle, L., Palmer, P. I., Wu, S., and Fu, T.-M.: Remote sensed and in situ constraints on processes affecting tropical tropospheric ozone, Atmos. Chem. Phys., 7, 815-838, 2007.

Thomas, J. N., Taylor, M. J., Pautet, D., et al.: A very active sprite-producing storm observed over Argentina, EOS, Transactions, AGU, Vol. 88, Nr. 10, 117-119, 2007.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 2561, 2007.