Referee 1:

We would like to thank the referee for taking the time to review our manuscript and the valuable feedback. We have corrected our manuscript according to the referee's comments and think it is now significantly improved.

This manuscript describes the atmospheric chemistry observations from the HALO aircraft during flights into a tropical storm and a tropical wave during the CAFE-Africa field mission. The tropical wave contained lightning and as a result significant enhancement of NO was noted. However, the tropical storm contained little or no lightning, and NO was not enhanced. Other chemical species that were considered include CO, O3, DMS, CH3I, and H2O2. The findings for all of these species were as expected, with enhancements of CO, DMS, CH3I, and H2O2 noted in the air parcels affected by deep convective transport from the marine boundary layer. O3 minima were also noted in the upper troposphere resulting from convective transport of low O3 boundary layer air.

The authors claim that this is the first report of in-situ chemical observations in deep convection in tropical cyclones with and without lightning. This is not entirely true. The authors need to reference the following papers and discuss their results in relation to them:

Newell, R., et al., (1996) Atmospheric sampling of Supertyphoon Mireille with NASA

DC-8 aircraft on September 27, 1991, during PEM-West A, J. Geophys. Res., 101, 1853-1871.

Roux, F., et al. (2020) The influence of typhoons on atmospheric composition deduced

from IAGOS measurements over Taipei, Atmos Chem. Phys., 20, 3945–3963, 2020

https://doi.org/10.5194/acp-20-3945-2020.

The Newell results show NO enhancements due to lightning (discussed further by Davis et al., 1996) in some portions of the storm (near eye wall), but not throughout the storm system. However, the observations reported by Roux et al. do not include NO, but should also be referenced.

The authors need to modify this claim in both the introduction and summary.

We would like to thank the referee for this comment and the suggested papers. However, we politely disagree with the referee about the lack in novelty of our work. Newell et al. describes in-situ measurements of trace gases in different parts of the Typhoon Mireille, 1991. They found indicators for convective uptake from the boundary layer to the upper troposphere which was strongest in the wall cloud area. The authors suggest lightning as one source of increased NO concentrations by in-situ measurements. The resulting photochemistry is further discussed by Davis et al. In contrast, we compare in-situ measurements in a tropical storm and a weaker tropical wave. Our central statement is that both systems developed deep convection but only the weaker tropical wave had lightning which we show by in-situ measurements. Roux et al. also reports evidence on convective transport by in-situ measurements, but the absence of NO measurements does not allow for the in-situ detection of lightning. Nevertheless, we agree with the referee that the suggested papers are very valuable in regards to in-situ aircraft measurement of convective uplift from the boundary layer in tropical cyclones and have added text to our manuscript.

Lines 89 ff.: Some studies have investigated trace gas concentrations and convective uplift in the upper troposphere through aircraft observations. Newell et al. (1996) reported in-situ observations of deep convection in the Typhoon Mireille in 1991 which they found to be strongest in the wall cloud region. Roux et al. (2020) found the convective uplift of boundary layer air as well as the inflow of lower stratospheric air to the upper troposphere based on measurements of CO, O_3 and H_2O during aircraft typhoon observations over Taipei in 2016. In contrast, studies of lightning activity within convective systems over the ocean and in tropical cyclones are predominantly based on satellite data and ground-based observations from the WWLLN (University of Washington; Abreu et al., 2010; Bürgesser, 2017; Hutchins et al., 2012b; Bucsela et al., 2019). Generally, data from in situ chemical measurements in the upper troposphere are sparse and to our knowledge, the in situ aircraft observation of deep convection in tropical cyclones accompanied by and in the absence of lightning depending on the stage of development has not been reported before.

Detailed Comments:

Lines 12-13: The ITCZ is not a broad area spanning +/- 20 degrees from the equator. It most often lies within this belt, but the convection associated with the ITCZ covers a much smaller range of latitude. Tropical cyclones may develop from ITCZ convection, but often they are not associated with the ITCZ.

Thank you. We have changed this sentence emphasizing that this band is not equal to but does include the ITCZ.

Lines 12 f.: Tropical cyclones are low-pressure systems evolving over warm tropical waters usually close to the equator (± 20°) - an area which includes the so-called Intertropical Convergence Zone (ITCZ).

line 17: 15 km or higher

We have corrected this.

Lines 16 ff.: In this region of high ocean temperature and intense solar radiation humid air can rise deeply into the troposphere up to 15 km and higher (Collier and Hughes, 2011; Deutscher Wetterdienst).

line 31: Deep Convective Clouds and Chemistry

Corrected.

Lines 35 f.: (…) the DC3 (Deep Convective Clouds and Chemistry) field campaign. the DC3 (Deep Convective Clouds and Chemistry) field campaign.

line 33: ....downwards due to gravity in the presence of supercooled water.....

Thank you, we have included this.

Lines 38 ff.: Collision of light ice particles moving upwards in cumulonimbus clouds and graupel particles moving downwards due to gravity in the presence of supercooled water induces electric charge separation which accumulates and discharges spontaneously as a lightning flash.

line 42: Add reference to Cecil et al. (2014, Atmos. Res.)

We have added the suggested reference.

Lines 47 f.: These results are in line with other published works e.g. Cecil et al. (2014), Xu and Zipser (2012) and Xu et al. (2010).

line 78: WWLLN: there are many journal references to WWLLN that are available to use here in addition to the website. Please include some of them.

Thank you for pointing this out. We have added a selection of references regarding the WWLLN.

Lines 94 f.: (…) and ground-based observations from the WWLLN (University of Washington; Abreu et al., 2010; Bürgesser, 2017; Hutchins et al., 2012b; Bucsela et al., 2019).

line 78-79: Data from in situ chemical measurements in the upper troposphere are sparse.

We have changed this.

Lines 95 ff.: Generally, data from in situ chemical measurements in the upper troposphere are sparse (…).

line 83: ...evidence of the chemical impacts of deep convection....

Changed.

Line 100 f.: The data are examined for evidence of the chemical impacts of deep convection and lightning activity.

Figure 2: It would be helpful to also show the 1200 UTC satellite image for MF12

We agree with the referee that the UTC 12:00 satellite image for MF12 would be useful in this analysis, but unfortunately no satellite images are available before UTC 18:00. We have added a note regarding the availability in the caption of Figure 2.

Flight tracks with color enhanced infrared imagery obtained from the Naval Research Laboratory Tropical Cyclone page (Naval Research Laboratory, 2020) for MF12 and MF14 (no image availability before MF12 UTC 18:00).

line 125: Deep convective transport generally occurs....

Corrected.

Line 148: Deep convective transport generally occurs in cumulonimbus systems accompanied by high cloud tops.

line 132: There are many other references for enhanced NO from lightning, and some of them should be given here. Examples:

Chameides et al., 1987 - JGR; Ridley et al., 1987 - JGR; DeCaria et al. (2000) - JGR; Ridley et al. (2004) - JGR; Pollack et al. (2016) – JGR

Thank you for these suggestions which we have added to our manuscript.

Lines 154 f.: In contrast, we expect enhanced NO concentrations in the presence of lightning (Pollack et al., 2016; Ridley et al., 2004; Lange et al., 2001; DeCaria et al., 2000; Chameides et al., 1987).

lines 140-141: ....concentrations wre overall larger for MF10 and MF12 than for MF14.... This makes more sense with regard to the following sentence.

We have changed that.

Lines 163 ff.: Besides the observed convective influence from the O_3 measurements, concentrations were overall larger for MF10 and MF12 compared to MF14.

line 145: ...was likely above... Line 121 says the aircraft was at similar altitude as cloud tops.

Thank you, we have corrected this. The aircraft is at a similar altitude as the cloud top in the morning and likely above the cloud top in the afternoon.

Lines 140 ff.: The flight altitude for MF12 at 18:00 UTC shown in Figure 2a was 14.4 km while overpassing an area of elevated clouds. The according temperature was - 68±1 °C, so the aircraft was likely above the cloud top. For MF12, the same area was passed in the morning at an altitude of 12.9 km, but no IR image was available. The temperature was - 56±1 °C. Assuming a similar cloud elevation in the morning, the research aircraft was at a similar altitude as the cloud top.

line 147: mention that the peak DMS on MF14 was ~50 ppbv, which is greater than on MF12

We have added this point to section 3.2.

Lines 172 f.: A maximum value of 58 ppt_v was reached passing the first cloud top area which is higher compared to the MF12 maximum.

line 157: ....for MF10 and MF12 (outside of convection)....

Corrected.

Lines 181 f.: Backward trajectories for MF10 and MF12 (outside of convection) (Figure S2 of the Supplement) show that the air originated from the African continent where lightning is frequent.

lines 161-162: ...convective processes with upward transport of low NO air from the marine BL

Thank you for the suggestion, we have added this.

Lines 186 f.: (…) the flight data were influenced by convective processes with upward transport of low NO air from the marine boundary layer.

line 189: ....ITCZ just south of the Cape Verde Islands. Lines 159-160 say it is due to lightning over West Africa.

The ITCZ is an area of enhanced lightning activity which is highest above continental areas and - at the latitudes we are looking at - predominantly West Africa. We have added text to clarify this.

Lines 184 f.: (…) the increased background level of NO for MF10 and MF12 was likely due to aged nitric oxide from thunderstorm activity over the ITCZ, mainly West Africa.

line 227: Need to mention that WWLLN is only detecting some small fraction of the total lightning that occurred because it has a rather low detection efficiency. Need to reference papers on WWLLN detection efficiency. See the WWLLN webpage.

We would like to thank the referee for noting this. We have added a section describing the WWLLN detection efficiency.

Lines 252 ff.: The WWLLN provides real-time lightning data covering almost the entire globe including oceans and remote locations. This is accompanied by a lower detection efficiency compared to local networks. Several studies have investigated this topic suggesting a WWLLN global detection efficiency of around 10% with constant improvements through an increasing number of stations (Holzworth et al., 2019; Bürgesser, 2017; Virts et al., 2013; Abarca et al., 2010). Allen et al. (2019) calculated a detection efficiency of around 12% for tropical Africa (LON -30° to 90°, LAT -30° to 30°) and of around 30% for tropical America (LON -150° to -30°, LAT -30° to 30°) for 2011. At the same time, the WWLLN is capable of detecting almost any storm with lightning (Hutchins et al., 2012a; Jacobson et al., 2006).