Responses to Review #1

We appreciate very much your comments on this manuscript, please find our responses below. (Line numbers are those in the original version of the manuscript.)

The authors use the advanced AirCore profiles operated by NOAA during the last years to validate the MOPITT and TROPOMI CO products. With the high measurement altitude of the AirCore measurements, the authors quantify the error introduced in MOPITT CO validation by the use of shorter aircraft vertical CO profiles extended upwards. The results are promising, and the error is estimated to be small. The AirCore profiles are also applied to validate the TROPOMI CO under both clear and cloudy conditions. The results are also consistent with previous studies. In general, the paper is well-written and easy to understand. I would like to recommend it to publish on AMT after addressing some minor comments/suggestions below:

lines 5-6 the unit is in mole cm-2 for MOPITT-AirCore, while in line 19 the unit is in % for TROPOMI-AirCore. Please be consistent, better to use %.

Thank you for catching this inconsistency. We have modified the abstract so MOPITT bias and SD values are now in %:
"Mean MOPITT/AirCore total column bias values and their standard deviation (0.4±5.5, 1.7±5.6, and 0.7±6.0 for MOPITT thermal-infrared, near-infrared, and multispectral retrievals, respectively; all in %) are similar to results obtained in MOPITT/NOAA aircraft flask data comparisons from this study and from previous validation efforts."

We have also added mean and SD of biases in % to Tables 1 and 2, and reworded the captions accordingly.

Same for the total column mean column bias values shown in Fig 4: we have added % values (only values in molec cm^{-2} were shown before). We have reworded the caption accordingly.

Finally, for completeness, we have added to Fig. 5 standard deviation values in molec cm^{-2} and to Table 3 standard deviation values in molec cm^{-2} (before they were all in % only).

Line 88 – 91: it is not so clear for me to understand the uncertainty of the CO. The authors said that "the total uncertainty is typically <5 ppb (Karion et al., 2013)", but they also pointed out that "stratospheric CO profiles have shown differences up to ~15 ppb". Besides the uncertainty of the CO at each altitude, it is more important to highlight the uncertainty of the CO total column (or within the AirCore measurement vertical range)

We have determined that the AirCore-derived total CO column error is ~1.3 ppb. This considers natural variability and measurement errors due to instrument and the AirCore sampling system between balloon flights spaced 15 minutes apart in the lower 80% of the atmospheric column. We assume errors of 15 ppb above this level based on other studies. As it turns out, AirCores flown on the same balloon have significantly less variability than those flown 15 minutes apart, suggesting that the majority of the uncertainty in the AirCore-derived XCO is due to natural variability and not uncertainties in the AirCore sampling or measurement systems.

Because we don't have both the actual and expected total CO column values to compute percent error, we estimate it as follows:
sigma(XCO) / AirCore-calculated XCO = 1.3 ppb XCO error / 71 ppb XCO= ~1.8%.

The manuscript has been reworded as follows:
“CO in AirCore samples is measured by cavity ringdown-spectroscopy (CRDS) at a precision typically less than 5 ppb (Karion et al., 2013) for ~ 0.5 Hz measurements. AirCore CO is, however, still considered a developmental product due to its use for correcting end-member mixing in other trace gas profiles. Comparisons of stratospheric AirCore CO profiles have sometimes shown differences up to ~15 ppb, which could be a result of AirCore tubing surface interactions or diffusion effects. It is also possible that chemical interactions or measurement interferences from other trace gas species or incorrect AirCore sample end-member assumptions have been made. Given these uncertainties and the number of independent CO measurements in each AirCore sample, we derive an estimated AirCore XCO uncertainty of ~1.3 ppb (2 sigma), equivalent to ~1.8 %.”

Figure 6, shows that the relative bias at one latitude (or at the same location) can vary from -18% to 28%. Have you ever investigated the cause for this, e.g. AirCore-satellite distance? cloud? surface? Meteorology?
We have not investigated this point in particular, but other results presented in the manuscript may help.

The AirCore/aircraft comparison results (Fig. 3) suggest that differences in the actual CO concentrations observed by each of the two instruments could be the cause. Biases are smaller when the instruments are closer in space and time (Fig. 3a, <15 km and <2 h) and increase as the distance between the instrument increases (Fig. 3b ad 3.c; <25 km and <50 km, respectively). Similarly, CO concentrations could differ between colocated AirCore and TROPOMI observations, which may be up to 12 h and 50 km apart.

We quantified the error introduced by clouds in land TROPOMI retrievals, which is lower (~2 % in average) than the spread mentioned in this comment.

For clarity, we added the following at the end of line 326: “The spread in biases shown in this figure may reflect differences in the actual CO concentrations observed by each of the two instruments, which may be up to 12 h and 50 km apart.”