

Response to Referee #1

We thank the reviewer for taking the time to review this manuscript and provide valuable and constructive suggestions/comments. We have addressed all the points one-by-one raised by the reviewer (copied here and shown in black text) along with the corresponding reply from the authors (in blue text, page and line number in revised version).

1) P1—L1: the title contains a few acronyms and would be complicated if spelling out their full names. I would recommend a brief title, such as “Intercomparison of arctic XH₂O observations from three ground based FTIR networks and application for satellite validation”.

The recommended title is brief and it is a very good suggestion. We are happy to have this new title, which is easier to understand for a broader community.

2) P1—L17: it is better to specify the time period here.

The time period for COCCON datasets is between March 6, 2017 and September 20, 2019. It is added according to referee’s comment (P1-Line18).

3) P3—L92: “ESA” to “European Space Agency (ESA)”. The full name of an acronym should be spelled out when it first appears.

We modified the text according to the referee’s comment (P3-line 92).

4) P4—L99: “European Space Agency (ESA)” to “ESA”, when the full name of an acronym is already mentioned before.

We modified the text according to the referee’s comment (P4-line 100).

5) P5—L139, L140: spell out the full name of WACCM and ESSD.

The WACCM refers to Whole Atmosphere Community Climate Model and ESSD refers to Earth System Science Data.

We modified the text according to the referee’s comment (P5-line 140 and 141).

6) P6—L174: does a similar airmass bias correction is applied to COCCON as used in TCCON?
please elaborate a bit more or a reference here.

The airmass dependent correction is mainly resulting from existing imperfections of the spectroscopic line lists. TCCON data are corrected for systematic errors representing spurious diurnal variation and therefore, adjusted to in-situ/WMO trace gas units by using a large number of in-situ aircraft profiles (Wunch et al., 2011). A similar posteriori-dependent airmass bias correction is applied to COCCON in order to also link COCCON data to the WMO standard via TCCON (Frey et al., 2019)

7) P7—L198: the formula here defines the total mixing ratio of H₂O (wet mixing ratio) rather than dry mixing ratio. In section 4.3, the map and radiosonde profiles are investigated. Are MAP H₂O a priori profiles also a wet mixing ratio? If so, the use of “XH₂O” as the volume mixing ratio of H₂O by integrating the a priori MAP profiles and radiosonde profiles in Figure 8 will confuse readers, since the XH₂O is defined as “dry-air mole fractions of water vapor” in the very beginning of this work.

The TCCON a priori profiles are treated as if it is a wet mole fraction (<https://tccon-wiki.caltech.edu/Main/AuxiliaryData>). Integrated radiosonde XH₂O and MAP XH₂O in Figure 8 and Figure 9 are updated to dry-air mole fraction of H₂O.

$$X_{H_2O} = \frac{P_{H_2O}}{P - P_{H_2O}} = \frac{f_{H_2O}}{1 - f_{H_2O}}$$

f_{H_2O} is the mole fraction of H₂O in the air.

8) P8—L215: could you elaborate a bit more on this seasonal variation of XH₂O? or a reference here.

The following explanations have been added (P8-219).

Specific humidity shows a strong positive correlation with temperature (Issac and Wijngaarden, 2012). Meanwhile, the higher precipitation in summer intensifies the higher atmospheric water vapor concentration. The evaporation from the snow-covered continent and frozen water surface is still much less, limiting the transport of water vapor into the atmosphere. This effect lasts until spring due to the slow warming of the surface (Wypych et al., 2018).

Isaac, V., and van Wijngaarden, W. A. Surface Water Vapor Pressure and Temperature Trends in North America during 1948–2010. *J. Climate*, 25, 3599–3609, <https://doi.org/10.1175/JCLI-D-11-00003.1>, 2012.

Wypych, A., Bochenek, B. and Różycki, M.: Atmospheric Moisture Content over Europe and the Northern Atlantic. *Atmosphere*, 9, 18, <https://doi.org/10.3390/atmos9010018>, 2018.

9) P17—L358: MUSICA IASI might be not considered as “network”. It is better to change to “...due to the choices for the calibration of XH₂O data product by either dataset.”

We modified the text according to the referee’s comment (P17-line 369).

10) P18—L366: it is better to keep the two subsections’ names consistency. Change “Comparison between TROPOMI and COCCON” to “Comparison between COCCON and TROPOMI” or the other way around.

We modified the text according to the referee’s comment (P18-line 377).