Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-96-AC4, 2020

Atmospheric Measurement Techniques Discussions

Interactive comment on "Total column water vapor retrieval for GOME-2 visible blue observations" *by* Ka Lok Chan et al.

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Received and published: 1 July 2020

We thank for the constructive comments. Our response to the comments is below. All page and line numbers refer to the marked-up version of the manuscript.

Chan et al. present a very interesting TCWV retrieval for GOME-2 which not only makes use of the H2O absorption in the blue spectral range, but also applies an iterative a priori water vapour profile approach. The authors are probably aware that Borger et al. (2020) developed a very similar approach. I have a few comments/questions that can hopefully help to further improve the overall high quality of the paper:

Response: We have to admit that the literature cited in the manuscript might not be up to date. Publication published in the past half a year was not included, as the algorithm

was developed while ago. We have now included your publication in the reference.

1. One great advantage of using the blue spectral range compared to the red spectral range is the higher sensitivity for the near-surface layers over ocean. Did the authors also consider to compare their TCWV data set to microwave satellite sensors? For instance SSMI/SSMIS are widely considered as reference measurements for TCWV retrievals over ocean because they can measure under all-sky conditions. It would be very important to see how good the TCWV from GOME-2 can match the TCWV from SSMI/SSMIS.

Response: We agree with you that SSMI/SSMIS provides measurements over ocean where the GOME-2 measurements in the blue band show higher sensitivity. On the other hand, the GOME-2 measurements in the red band have been validated against SSMI/SSMIS data and the two data sets show very good agreement (Grossi et al., 2015). The comparison between GOME-2 blue and red band retrieval also show excellent agreement. Therefore, we can expect that the new data set matches the SSMI/SSMIS observations. In addition, we have compared the new product to sunphotometer and radiosonde measurements and both results are consistence. As the focus of the manuscript is the algorithm development, we cannot handle everything within one manuscript, so we would like to leave the comparison to SSMI/SSMIS data for the follow up validation study.

2. A similar question is related to the use of AERONET data as reference. As the authors mention it themselves, TCWV from AERONET is potentially affected by biases. Have the authors had a look at TCWV from ground-based GPS measurements from SuomiNet or IGS? In comparison to AERONET, these GPS networks can conduct TCWV retrievals for all-sky conditions at a very high accuracy and provide continuous time series of TCWV for their measurement stations (e.g. SuomiNet TCWV data are available every 30 min). Such a comparison would further improve the confidence of the new retrieval.

Response: Thanks for the suggestion. All measurements have their own advantages and disadvantages. The uncertainty of GPS data is also strongly dependent on temperature and pressure profile. For sure, the new product may benefit from comparing to GPS data. However, we have already compared the GOME-2 TCWV product to three different measurements and we cannot take care everything within the manuscript. Therefore, we would like to leave the comparison for the next validation study.

3. It is kind of surprising to see that the GOME-2 TCWV retrieval uses HITEMP2010 /HITRAN2012 as H2O cross-section, whereas Wang et al. (2019) (for OMI) and Borger et al. (2020) (for TROPOMI) found a significantly better agreement to reference measurements by using HITRAN2008. The use of HITRAN2008 over HITRAN2012 is also supported by the LP-DOAS results in Lampel et al. (2015) (see Table 8 in their paper). What is the rationale for still using HITRAN2012?

Response: We have carefully checked the available cross sections while developing the retrieval algorithm. The water vapor cross section from the HITRAN 2008 data set is also included in the sensitivity study. Water vapor SCDs retrieved with the HITRAN 2008 cross section are 1-2% higher than the one retrieved with the corrected cross section in HITEMP2010. The enhancement of SCDs is more significant over higher altitude and would further enhances the positive bias over these areas. In addition, the root mean square of the spectral fit residual using the HITEMP 2010 cross section is slightly ($\sim$3%) smaller. Therefore, we decided to use the HITEMP 2010 cross section instead of the other one. We have provided this information in the manuscript (page 11, line 1-6).

4. Although it is very reasonable to use ERA-Interim for the statistical analysis, isn't there potentially the risk that the data quality of the ERA-Interim water vapour profile scan vary a lot e.g. depending on which measurement data have been used during the data assimilation process? At least this was one of the reasons for Borger et al. (2020) to only use water vapour profiles from a consistent measurement data set (COSMIC in this case) for setting up their iterative a priori water vapour profile retrieval scheme.

Response: The ERA Interim data assimilated multiple sources of data including radiosonde and many ground and satellite based remote sensing observations, which could potentially avoid bias from single source. In addition, we are using statistical data over a long period (11 years) the bias or uncertainty caused by different observations is expected to be negligible compared to other sources of error. A more comprehensive comparison of different data assimilation results would provide a more solid conclusion on this topic, however, it is beyond the scope of this manuscript.

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