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Comment on amt-2021-144

Ruediger Lang (Referee)

Referee comment on "Total water vapour columns derived from Sentinel 5P using the AMC-DOAS method" by Tobias Kuchler et al., Atmos. Meas. Tech. Discuss.,
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The paper by Hummel et al on the

"Total water vapour columns derived from Sentinel 5p using the AMC-DOAS method"

provides a detailed discussion of the results of total column water vapour (TCWV) retrievals from the Sentinel-5p TROPOMI instrument using the AMC-DOAS retrieval methods originally developed by Noel et al.

The results are compared in particular to the most recent ECMWF ERA5 reanalysis model data dominated by thermal infrared, GPS, and radiosonde water vapour profile data assimilation, as well as to other, model independent, retrieval results, in particular MPIC DOAS operating in the UV region, AMC-DOAS TCWV results from the GOME-2 instrument on Metop, and TCWV results from the SSMIS microwave sensor.

Additional corrections on the impact on surface albedo and elevation, as well as empirical corrections, potentially due to instrument artefacts, have been applied to the AMC-DOAS retrieval results from S5p.

The authors find good agreements between all data-sets with typical standard-deviations expected for any TCWV retrieval validation, due to differences in spatial scales and resolutions, as well as low mean biases, in particular also to the ERA5 model.

This is in contrast to previous studies where comparison to reanalysis model data revealed larger biases, typically also due to statistical effects of comparing "cloudy" model results

with typically cloud free or low cloud) retrieval results. This fact points to significant improvements in the reanalysis data modelling of small-scale relative humidity and clouds, however not discussed by the authors. Also in this respect to the paper may serve as a good validation of the ERA5 re-analysis data, in particular in regions where assimilated data in the reanalysis fields is sparse, like in remote areas over land, and TCWV from thermal infrared missions biased because of lack of thermal contrast.

The impact of the additional corrections applied to S5P version of AMC-DOAS is significant, in particular with respect to surface elevation, albedo and clouds. While the elevation related effects on the TCWV are obvious and discussed when comparing to the "non-corrected" Metop-B AMC-DOAS results, the discussion on the additional albedo and cloud effects are less conclusive. But the authors expect that the same correction should be principally always applied, because they are basically instrument independent, and therefore would also apply for the GOME-2 data-set. This should indeed be followed up in future work.

The paper is well written and I can recommend it for publication in AMT.

The general introduction is however missing an overall conclusion with respect to the significance of the TCWV products derived from the UV-visible to NIR spectrum, in addition to the large amount of data-sets on TCWV and profile information existing and extensively used from the thermal infra-red and MW region. This is important in the context of a longer discussion on the application range of these data-sets, linking back to the discussion referred to above. The relevance of these visible data-sets is their coverage and (relatively) weaker dependence on surface type, as well as their sensitivity to the surface WV profile layers, ie. their accuracy w.r.t. the total column.

Being independent of model re-analysis data, they can be used for the validation of the latter. It would improve the motivation of why an operational WV product from S5p, as well as from S5 should be made available in the future.

Specific comments:

Section 3.4 on the empirical correction:

There seems no indication (from experience from other retrievals?) of what causes the artefacts. Usually such across track features (which are frequently observed for such data, also in other VIS/NIR spectrometer missions) can be typically the result of an additive

offset: i.e. stray-light, or a problem in the solar irradiance spectrum. What exactly is used for the latter? Experimenting with I0 (using artificial offsets or a very low TWVC (polar region) reference spectrum) potentially can reveal the origin.

Can it be that the surface albedo correction already takes out a significant part of the feature over land? Since, if the artefact is not visible over land it can hardly be an instrumental feature.

Section 4.3, on the assessment of spatial features:

It should be generally not be surprising to find a feature related to vegetation in the AMC DOAS retrievals given is usage of measurements from the red-edge of the spectrum. The behaviour of MPIC DOAS in this respect is not surprisingly much different. Reducing albedo variations was in the end a large motivation I would assume (not only higher albedo over water as stated in the paper, and spectral regions covered by future instrumentation) to move towards the blue. This specific sensitivity of a TCWV retrieval operation around 700 nm should be better highlighted and discussed in the paper.

Editorials:

Introduction, l.21: Full stop missing.

Section 3.3.1, l9f: Sentence should be improved.

Acknowledgments: Acknowledgment to EUMETSAT providing GOME-2B level-1 data missing.