Interactive comment on “Evaluation of MUSICA MetOp/IASI tropospheric water vapour profiles by theoretical error assessments and comparisons to GRUAN Vaisala RS92 measurements” by Christian Borger et al.

Anonymous Referee #1

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General Comments

This manuscript presents IASI water vapour VMR profiles retrieved using the MUSICA algorithm and evaluates them against coincident GRUAN radiosonde profiles measured at three stations representing tropical, mid-latitude, and high-latitude conditions. The MUSICA MetOp/IASI water vapour retrieval method is described, averaging kernels and DOFS are presented, and the error budget terms are thoroughly evaluated. Vertical profiles of the errors are used to identify the dominant sources of uncertainty as a function of altitude. A total of 100 coincident GRUAN profiles are used for validation.
These are regridded to the IASI altitude grid and smoothed with the averaging kernels prior to the comparisons. Correlation plots at three altitudes and vertical profiles of the mean relative difference and its standard deviation are used to quantify the agreement between the two datasets. Overall, IASI and GRUAN differ by less than 25% between 1.5 and 10 km altitude, and are within the errors for the two data products. The authors conclude that the MUSICA MetOp/IASI retrieval processor provides water vapour VMR profiles with good accuracy and captures variations between 1.5 km above ground up to the tropopause with a precision that is consistent with the theoretical error assessment.

The manuscript is clearly and concisely written and I recommend publication after the minor comments below are addressed.

Specific Comments

Page 4, lines 9-15 – Se is used to denote the error covariance matrix in both Eqs. 8 and 9, implying that these are the same. However, the former is due to parameter uncertainties and the latter is due to measurement uncertainty. Rename one of them to clearly differentiate?

Page 6, line 12 – 100 coincident IASI-GRUAN profiles is not a large number for a validation study, particularly for such a highly variable species as water vapour, even though they do cover three representative sites. Some discussion to justify that this number sufficient for good statistics should be added, perhaps citing other water vapour validation studies.

Page 7, line 5 – Provide the collocation criteria for the Manus Island comparisons, as done for Lindenberg (lines 14-15). Similarly, provide them for Sodankyla at line 22.

Page 7, lines 17-19 – Shouldn’t this information about the Manus Island IASI data version be included in Section 3.2? Comment on whether there are differences between v4 and v5. Also in Section 3.4, state which version is used for Sodankyla.
Page 10, line 12 – The text says that “The right panel of Fig. 5 illustrates that . . . a cirrus cloud has a weaker dependency on wavenumber than a dust layer.” However, in this figure, the line for cirrus cloud (green) decreases more with wavenumber than does the line for dust (blue), suggesting that cirrus has a stronger dependency on wavenumber. Clarify.

Page 11, line 4 – Here and elsewhere, why use “error pattern profile” rather than “error profile”? The $x_e$ in Eq. 7 and plotted in Figs. 7, 8, and 9, is just defined as the error. Delete “pattern” throughout, or define it.

Page 11, lines 15-20 – This paragraph doesn’t comment on the oscillations seen in the lower panels of Fig. 7. Add some discussion.

Page 14, Section 5.1 and Figure 11 – In the text or the figure, provide the slopes in linear space and the correlation coefficient $R^2$ for each of the panels.

Page 14, line 18-19 – Explain why the two terms in Eq. 15 are approximately equivalent.

Technical Corrections

Page 1, line 8 – degreeS
Page 1, line 13 – coincidENT
Page 1, line 15 – but never exceeds 30%
Page 1, line 17 – in accordance WITH the
Page 2, line 10 – aircraft AND satellites
Page 2, line 16 – delete respective
Page 2, line 34 – outcomeS
Page 3, line 3 – introduction to the
Page 3, line 8 – THE forward model F), which relates the
Page 3, line 9 – add period after equation
Page 3, line 18 – delete level
Page 3, line 20 – whereby THE kind
Page 4, line 21-22 – reorder cited references
Page 4, line 22 – delete ranging
Page 4, line 27 – HITRAN 2016? could state this explicitly
Page 5, line 3 – a priori PROFILE
Page 5, line 11 – by THE US Geological Survey
Page 5, line 17 – differences COMPARED to the
Page 6, line 11 – observationS
Page 6, line 16 – could change “mid-latitudinal” to “mid-latitude” throughout
Page 6, line 20 – FOR more details
Page 7, line 5 and 13– coincidences WITH
Page 7, line 13 – representative OF all
Page 7, line 16 – As for Manus
Page 8, line 14 – Fig. 4 (not 5)
Page 9, line 7 – delete hypothetically
Page 9, line 13 – coverage BY opaque
Page 10, line 24 – The error profiles shown are
Page 11, line 32 – maximUM errors
Page 12, line 2 – in Fig. 8.

Page 12, line 4 – Strictly, Fig. 9 shows the influence of cloud type on the errors, rather than the retrieval.

Page 12, line 5 – Now using “humidity” as equivalent to water vapour VMR – is that correct?

Page 12, line 10 – Fig. 9 middle row shows results for clouds at 4.9 km, not 3.0 km, at Manus Island and Lindenberg. Clarify this in the discussion.

Page 12, line 10 – Elsewhere, altitude above ground is referenced, rather than altitude above mean sea level. Check that terminology is correct.

Page 12, line 13-14 – errors are more than 10%.

Page 12, line 18 – (FOR details)

Page 12, line 21 – This differs from the

Page 12, line 22 – for THESE different

Page 12, line 25 – “So we have to” – rather colloquial

Page 12, line 31 – put ON the . . .

Page 13, line 1 – thereby preventing the correction from producing strongly oscillating profiles

Page 13, line 32 – and in situ data identify well

Page 14, line 8 – delete if

Page 14, line 9 – VMRs (rather than concentrations – two references)

Page 15, line 5 – agreement WITH the

Page 15, line 14 – representative OF three
Page 15, line 28 – giving the study presented here a good
Page 16, line 2 – The MUSICA MetOp/IASI data presented here are
Page 17, line 7 – radiosonde CAN be
Page 17, line 14 – depicts the correlated
Page 17, line 26 – ground to 5-20%
Page 22, Figure 1 – spectrUM
Page 25, Figure 4 – degreeS; spelling of Lindenberg is incorrect in the figure
Page 26, Figure 5 – Since (4-6km) altitude range is given for Dust in the legend, could add (13-14km) for Cirrus.
Page 27, Figure 6 – error profiles derived from instrument noise
Page 28, Figure 7 – delete different
Page 29, Figure 8 – Font size for site names is different from Figures 7 and 9. Also smaller in Figure A.2.
Page 31, Figure 10 – x-axis label is Water vapour, but H2O used in other figures. In caption: MetOp/IASI retrieval OF H2O profiles.
Page 32, Figure 11 – Add linear slopes and correlation coefficient R2 to each panel. In caption: Red and black colourS