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Interactive comment on “Retrievals of formaldehyde from ground-based FTIR and MAX-DOAS observations at the Jungfraujoch station and comparisons with GEOS-Chem and IMAGES model simulations” by B. Franco et al.

Anonymous Referee #3

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General Comments

This manuscript describes the retrieval of vertical profiles of HCHO at the high-altitude Jungfraujoch station from July 2010 to December 2012 using both FTIR and MAX-DOAS techniques. The retrieval methodologies are compared and the vertical sensitivity of each technique is assessed. The measurements are interpreted using the GEOS-Chem and IMAGESv2 chemical transport models. The seasonal cycle of HCHO is investigated, and is found to be consistent between the two datasets, while the mod-

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els generally underestimate summertime HCHO. Overall, the manuscript provides a clear and comprehensive description and validation of an optimized FTIR retrieval strategy. The results should be of interest to the FTIR, DOAS, and CTM communities. The manuscript is well written and is suitable for publication in AMT after the minor comments below are addressed.

Specific Comments

Page 10721, line 2 – Isn't 1/MOPD used more often than 1/2MOPD? For boxcar apodization, the first zeros of the sinc function are separated by 1/MOPD. A separation of 0.5/MOPD implies the Rayleigh resolution criterion (sinc² ILS of a grating spectrometer), where two sinc² features are resolved when the peak of one is located at the first zero of the other. Using RES = 0.5/MOPD implies MOPD of 125 to 83 cm for RES = 0.004 to 0.006 cm⁻¹, which is lower than the usual 250 cm for NDACC FTIR measurements.

Page 10727, line 3 – Comment on why the correlation length for MAX-DOAS (0.2 km) is so much smaller than that for FTIR (3 km).

Page 10733, para 1 – Could comment on why the HITRAN 2012 data is causing problems. Which interfering species are causing the issues?

Page 10733, lines 18-20 – This gives a progressive increase in temperature error, but Table 2 just says “±4 K around NCEP noon profile”. Which is correct?

Page 10734, para 1 – Revise this paragraph to address each of the errors in Table 3, in turn. Some error sources seem to be missing from the text (smoothing and noise errors of 9.1%). How is the 20% error on the O₄ cross section related to the 6.3% uncertainty related to aerosols?

Page 10734, line 24 – Are the FTIR and MAX-DOAS measurements also daily averaged?

Page 10740, lines 8-10 – “Indeed, the mean fractional differences between the models

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and the FTIR data are generally consistent with the mean fractional differences calculated between the models and the MAX-DOAS observations (Table 4).” This sentence does not seem consistent with the results in Table 4, e.g., compared to IMAGES, the mean fractional differences for FTIR is negative and those for MAX-DOAS is positive. And for GEOS-Chem, the differences wrt FTIR are twice as large as those for MAX-DOAS. Clarify this discussion here and in the Conclusions, page 10746, lines 7-11.

Page 10740, line 22-25 – Is the slope expected to be linear at these altitudes? Explain why.

Technical Corrections

Page 10717, line 3 – associated with

Page 10718, line 4 – part of the NDACC (Network ...)

Page 10718, line 20 – Is there a reference for GEOS-Chem v9-01-03 ?

Page 10718, line 20/21 – total columns ... partial columns

Page 10719, line 5/6 – The measurement site ... 2. A short description ...

Page 10719, line 10 – reports the results of

Page 10720, line 15 – in Northern Italy ... of the Alps

Page 10721, line 2 – inverse of

Page 10723, line 23 – consists of two

Page 10723, line 28 – then used as a priori

Page 10724, line – “In brief, it is a dual-channel system composed of two grating spectrometers covering the UV (300–390 nm) and visible (400–580nm here, instead of 400–720nm in Xianghe) wavelength ranges and connected to cooled CCD detectors.” Provide some context for Xianghe – this is the only mention of it except in the title of the Deng et al. reference.

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Page 10726, line 1/2 – example of a DOAS fit . . . same date as

Page 10726, line 10 – path through the atmosphere

Page 10715, line 15 – as the forward model . . . (also suggest starting a new paragraph at the end of this sentence)

Page 10726, line 25 – Explicitly state that the $S_{a,e}$ and S_a matrices are for aerosols, as there is some ambiguity with HCHO.

Page 10727, line 26 – change “lumping” to combining?

Page 10728, line 20 – closest pixel to

Page 10729, line 29 – consists of HCHO . . . closest pixel to the station

Page 10730, line 17 – Here and throughout the paper, change “1 – sigma” to “1sigma”. The former looks like the difference between 1 and sigma.

Page 10731, line 12 – reduced to 50%

Page 10732, line 2 – from individual FTIR solar spectra

Page 10732, line 5 – Clarify what is meant by “with an assumed variability close to 50%”. It is not clear what this refers to.

Page 10732, line 19 – Delete “remained”.

Page 10732, line 21 – to the 10% uncertainty assumed here

Page 10733, line 4 – parameters have

Page 10733, line 13 – Make clear that this is the “Retrieval algorithm-related” term in Table 2 – use same terminology as in the table.

Page 10733, line 26 – Change “2 – sigma” to “2sigma”.

Page 10733, line 22 – columns on the

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Page 10734, line 2 – The error budget on the retrieved MAX-DOAS HCHO VCDs is ...

Page 10734, line 21 – For this purpose,

Page 10734, line 25 – averaging kernels and a priori profiles from the ...

Page 10735, line 5 – CTM outputs

Page 10735, line 9 – confronted by MAX-DOAS

Page 10735, para 2 – Change “1 – sigma” to “1sigma” (three places). Also page 10738, line 29; page 10739, lines 13 and 29, page 10740, line 20, etc.

Page 10736, line 9 – representing a seasonal amplitude

Page 10736, line 26 – by an amplitude of

Page 10737, line 8 – from Europe to Ny Alesund (correct?) occur especially...

Page 10738, line 29 – associated with the

Page 10739, line 27 – IMAGES columns underestimate and overestimate the FTIR

Page 10740, line 1 – associated with these

Page 10740, lines 7,11,19 and Table 4 caption – CTM (or CTMs')

Page 10740, line 17 – for the FTIR and

Page 10741, line 8/9/10 – MAX-DOAS profiles ... directly above ... associated with the

Page 10741, line 14 – on average

Page 10741, line 16 – due to lower elevation

Page 10741, line 19 – Delete “instruments”.

Page 10741, line 20 – What is meant by “efficient” measurements? Use a better de-

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scription.

Page 10742, line 3 – of the CTM outputs relative to the FTIR profile extend throughout

Page 10742, line 11 – consist of

Page 10743, line 3 – equal to

Page 10743, line 5 – consistent with

Page 10743, line 7 – equal to

Page 10744, line 4 –CTM

Page 10744, line 10 – precursor concentrations

Page 10744, line 24 – associate with

Page 10745, line 8 – an OEM retrieval process. The MAX-DOAS strategy consists of deriving DSCDs. . .

Page 10745, line 20 – HCHO columns and profiles simulated by

Page 10746, line 1 – total column

Page 10746, line 3 – Considering that

Page 10746, line 5 – lower-tropospheric

Page 10746, line 7 – CTM

Page 10746, line 12 – remote location

Page 10746, line 17 – combined with CTM outputs . . . an important background test site

Page 10763, Table 4 caption – Mean fractional differences (in % \pm 1sigma), calculated . . .

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Page 10763, top row of Table 4 – 3.6-3.8 km MAX-DOAS column

Page 10764, Figure 1 caption – Typical examples of HCHO spectral fits at ISSJ

Page 10767, Figure 4 caption – Change “1 – sigma” to “1sigma”. Line 7: associated with

Page 10768/9, Figure 5/6 captions – Change “1 – sigma” to “1sigma”.

Page 10770, Figure 7 caption – smoothed CTM . . . and the model outputs

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