Summary

This is a well-written and topical paper worthy of publishing in AMT, with some comments addressed. The authors use a spectrometer covering a wide spectral region to investigate differences in the retrieved profiles from different wavelength regions of the mid-near infrared spectrum. As the majority of ground-based Fourier transform spectrometers around the world use a series of spectral filters, this type of comparison allows for H2O and @D profiles retrieved from different filter regions to be used interchangeably.

Major comments:

My biggest concern in this paper is an ongoing question regarding the spectroscopic parameters. Spectroscopic parameters from Hitran 2008 were used, but modified to minimize the systematic differences between the FTIR and sonde data (page 3111 lines 2-3). While I understand that the adaptations to the spectroscopic parameters will be presented in a separate paper yet to be published, I felt like I needed to know a little more about the changes to fully understand these results, and to have faith in the conclusions. Were the reported changes made to the pressure broadening and line intensity coefficients in all wavelength regions, and consistently across the spectral ranges or by varied amounts for individual features? Did one of the three spectral regions have better Hitran parameters than another? And how did these changes affect the retrievals? If spectroscopic parameter changes are required in each wavelength region in order to achieve good agreement between the spectral ranges that are shown, it is important that this is highlighted, as the key conclusion to this work is that retrievals from these three regions are comparable. This is highlighted when it says in the conclusions (page 3116, line 17) "when applying optimized spectroscopic parameters, the different water vapour profiles are very consistent". Because the reader does not know what sort of changes these optimized parameters had on the retrieved results, it is hard to know whether measurements that have already been made in these spectral regions are comparable or not.

A Voigt line shape model is the standard model that is used for infrared radiative calculations. However it is known from different laboratory studies (e.g. D'Eu et al., 2002; Tran et al., 2007; Wagner and Birk 2009) that a Voigt line shape model is not able to well describe the actually measured line shape. These laboratory studies recommend using a speed-dependent Voigt line shape instead of a Voigt line shape. Schneider and Hase (2009a) demonstrated that applying a speed dependent Voigt line-shape is very important for the ground-based remote sensing of water vapour profiles in the 785-1325 cm^{-1} region. Furthermore, they documented inconsistencies in the line parameters (line position, strength, and pressure broadening) in this spectral region. These inconsistencies are small and within the limits of the uncertainty range as given by the HITRAN files (i.e. they are absolutely consistent with the HITRAN data), but they cause significant errors in the retrieved profiles. Schneider and Hase (2009a) suggest new line parameters (modifications within the uncertainty range given by HITRAN file) for which the errors in the retrieved profiles are much lower.
In a new study Schneider et al. (2010c), examined the effect of a speed-dependent Voigt line shape model on $H_2{}^{16}O$ and $HD^{16}O$ profiles remotely-sensed in different spectral infrared regions: 790-880 cm^{-1}, 1085-1205 cm^{-1}, 1220-1330 cm^{-1}, 2650-2725 cm^{-1}, 2815-2980 cm^{-1}, and 4560-4710 cm^{-1}. This new study confirms the Schneider and Hase (2009a) results and shows that a speed dependent Voigt line shape model is a key for high quality ground-based remote sensing of water vapour profiles in the middle as well as the near infrared spectral region. Schneider et al. (2010c) make a rough estimation of the strength of speed-dependence (and of small systematic errors in the HITRAN line intensities and pressure broadening parameters). The obtained speed-dependent Voigt line-shape parameters are in good agreement to the values that are typically obtained from laboratory measurements.
For the retrievals of this work we apply "an optimized line shape model and optimized line parameters", which means a speed-dependent line shape model for all spectral regions with the parameters estimated in Schneider et al. (2010c) and for the 785-1325 cm^{-1} we additionally take into account the inconsistencies found in Schneider and Hase (2009a).

Further, if the sondes were used to improve the spectroscopy so as to minimize the differences between the sonde and FTIR comparison, it seems that the comparison between the two, as proof of good H2O measurements from the FTIR (page 3112/Figure 6 and 7), is thus a bit circular. I would feel more comfortable with this if both the standard and adapted line parameters were presented, or at least the difference that these modifications made to the comparison were better shown.

We optimized the line parameters with comparisons between RS92 radiosonde and ground-based FTIR water vapour profiles from Izaña and from Table Mountain Facility. Both comparisons document the importance of the speed-dependent Voigt line shape. The strength of the speed-dependent Voigt line shape is estimated from the Table Mountain Facility comparisons however, the estimation is in agreement with

laboratory studies I don't think that pointing out to the good RS92-FTIR agreement is circular argument: a Voigt line-shape model is required from laboratory experiments and we show that applying such a line-shape model (together with many other complex analysis techniques as reviewed in Schneider and Hase, 2009b) can in deed lead to a very good agreement between the two techniques. In Schneider et al. (2010c), which is currently under revision, (as well as in Figure 5 of Schneider and Hase, 2009b) it is clearly shown that by a Voigt line shape model we cannot achieve this good agreement.
In Schneider et al. (2010c) we document in detail how the optimized parameters improve the agreement between radiosonde and remotely-sensed profiles. Showing these plots again in this AMT paper would deviate from the actual scope of the paper: documenting the consistency as is and not the developments/improvements that have been necessary to achieve this consistency. Furthermore, the line parameters are just one issue. During the last years there have been many other developments/improvements that are mandatory for a ground-based analysis of water vapour profiles: simultaneous temperature retrieval (Schneider et al., 2006a), $H_2{}^{16}O$-$HD^{16}O$ interspecies constraint (Schneider et al., 2006b), consideration of atmospheric emission (Schneider and Hase 2009b), and optimal line parameters (Schneider and Hase 2009a; Schneider et al. 2010c;). All these developments are reviewed in Schneider and Hase (2009b).
We see from the concerns of the Referee that the Schneider at al. (2010c) paper is important and we will delay the final AMT publication this paper until the Schneider et al. (2010c) paper will have been published.

Finally, a key assumption made in this paper is that spectroscopic parameters are the major error source for the retrieved profiles, and thus that this paper provides a good empirical assessment of the FTIR data. While it is likely that this is true, I would like to see an error analysis for retrievals from each of the wavelength regions presented in this paper. A simple table would be nice, allowing the user to compare the effects of the parameters that contribute to these retrievals. A little more information regarding the retrieval set-up, including what was used for a priori information etc would also make this paper more useful for the FTIR community.

We will resume the error estimations published already in other papers: Schneider et al. (2006a;b) and Schneider and Hase (2009b) in form of a Table.
The fundamental retrieval set-up is described in detail in Schneider and Hase (2009b). We will add a brief summary of this and also add more specific details about the retrievals in the different regions: interfering species, etc.

Minor comments:

Introduction: Because the stated aim of this work is to allow retrievals from different spectral regions to be compared, I think it would be good if the introduction mentioned the spectral regions that have been used in the existing ground-based FTIR H2O measurement literature (e.g. Palm et al, Sussman et al), and perhaps referenced them in comparison to the integrated water column results presented in Figure 8. It would also be interesting to state which of these spectral ranges (if appropriate) the satellites measuring H2O profiles in the infrared use.

We could insert these citations in the context of a brief review of all the existing literature about ground-based FTIR water vapour retrievals: Hase et al. (2004), the Schneider et al. papers, Sussmann el al. (2009), and Palm et al. (2010). However, the Sussmann el al. (2009) and Palm et al. (2010) studies are limited to $H_2{}^{16}O$ total column amounts, which is not the focus of our paper. Of course high quality $H_2{}^{16}O$ total column amounts is a side product of our profile retrievals, but the main focus of our work are profiles, not only of $H_2{}^{16}O$ but also of δD.

Page 3107, lines 0-5: I think at last count there were 22 NDACC MIR spectrometers and 15 TCCON spectrometers, though it is probably worth noting that in many (if not most) cases these spectrometers are one and the same, just measuring in different spectral regions.

Ok.

Page 3107, line 22: It may be helpful to add that the MkIV was measuring direct solar absorption spectra from the ground in this case, either here or in the description of the instrument during MOHAVE on page 3109/3110, as it is a well known instrument for balloon/aircraft flights as well.

Ok.

Page 3107, line 30 –Page 3108 line 1: "Since errors in the spectroscopic parameters are the main error source" – see note above regarding error analysis, or at least reference where this claim came from.

Ok.

Page 3109, line 13: Please define FTUVS

Ok.

Page 3110, lines 10-15: It looks like these spectral regions include a range of microwindows – have these been selected specifically to exclude interfering species? If not, please mention which other species have been fitted.

Ok.

Page 3111, line 16: Please define the altitude ranges that you have called the "lower, middle and upper troposphere". This will help the readers link your altitude resolution to the observed structures in Figure 6.

Ok.

Page 3111 line 20: It is not clear in the figures that there is more detailed profile information in the lower troposphere in the mid infrared than in the near infrared – the averaging kernels look very similar!

Ok, we will remove this sentence.

Page 3113, line 8: "is well able to detect the relatively large. . ." I'm not sure this is "well able to detect". It does detect, but the differences are well over 100%, which I wouldnot say is "well able to". It also does not detect the relatively large feature on the 20th.

Ok, we will change this sentence to "[…] the FTIR system detects the unusual large water vapour amount [...]"

Page 3113, lines 8-14: This section could probably use some reference back to your altitude resolutions given on page 3111. On day 091020 the broad enhanced region is not observed, while it is observed on 091023 over a comparable altitude range. The small feature like that on day 091022 is not detected at all. Depending on your definition of low, middle and upper troposphere, I think that with the quoted resolution of 2-3 km at this altitude, the retrieval should have at least slightly picked this one up? Are these results consistent with the altitude resolving widths that you determined from the averaging kernels? While I think you've done a good job showing that we expect that detailed features will be smoothed out, it is not clear to me why we do not see any enhancement at all for many of these narrower features, especially if the averaging kernels show altitude resolution of just a few kilometers.

The black stars show the RS92 (vertically highly resolved) after convolution with the averaging kernels. It documents thereby how the fine structures are smoothed out by the remote sensing system. In my opinion this is clearly described in Section 5 in particular by Eq. (1). We will see if we can make this even clearer.

Page 3113 lines 19-20: "On this day the troposphere is very dry (compare Fig. 6) and the observation of a slightly more humid airmasses by the RS92 if compared to the FTIR can be responsible for this outlier": While your explanation may well be correct, from Fig 6, it looks like the two (smoothed) profiles are in very good agreement (and the high resolution profile doesn't suggest that the RS92 measured a humid air mass) – is it possible that the difference in the amount of water between the profiles is similar to the others, but this translates to a bigger percentage because there is already such a small amount there?

Yes, this is what I try to say.
By the way: we will correct "airmasses" to "airmass" everywhere in the text.

Figure 7: Zooming these plots in to -50 – 50% would make them easier to read.

Ok.

Page 3113 line 27 – page 3114 line 8 and Figure 8: This comparison is apparently for column integrated water vapour. If this is the case, then the altitude range that has been integrated for each of the regions needs to be specified. On the figure, a single altitude is given, adding to this confusion. It would also be good to see the variability in the column compared with that found in previous FTIR water column studies.

I think there is a misunderstanding. Figure 8 shows column integrated amounts (only the left panels) as well as for profiles: mixing ratios at 3, 5.5 and 8km. In my opinion this is clear from the plot, the Figure caption, and the text, but we will try to further improve the Figure caption in order to avoid any misunderstanding.

For calculating the column mixing ratio we integrated the whole profile from the surface up the uppermost atmospheric model altitude, which in the case of the water vapour retrievals is 50km.

Figure 8: The red and blue lines should be identified.

Ok, these lines are mentioned in the caption but the colors are not well attributed. We will correct this in the Figure caption.

Page 3115, line 1: "It is very likely due to inconsistencies between the spectroscopic line parameters. . ." – again I'm a little confused here – weren't the line parameters changed so that both regions well matched the sondes? In which case, wouldn't the inconsistency have to be due to something else? Clarifying the extent of the adaptations would help in understanding some of these claims.

The line adjustment we performed is rather rough (see reply to major comments). In order to make this clearer we will change the term "optimized line parameters" to "line parameters adjusted for speed-dependence".

Page 3116, line 17: "Agreement with the Vaisala RS92 radiosonde profiles is within 20%". This needs to be quantified: "On most days, agreement with the Vaisala RS92 profiles, when smoothed with the FTIR averaging kernels, is within 20%". Even with the smoothing, it is greater than 20% on 091028, and, at some altitudes, on 091020. Without the smoothing, the differences are substantially larger. While the FTIR can clearly distinguish between the lower, mid and upper troposphere, it is not retrieving a profile of the resolution measured by the Vaisala and it is important that this distinction is identified.

Ok, we will say "is generally within 20%".

Technical corrections:

Page 3112, line 1: Switch the order of this sentence slightly for clarity, from "larger only than 75% for altitude below. . ." to "larger than 75% only for altitudes below. . ."

Page 3113, line 20: airmasses should be "airmass". Also "can" might be replaced with "may" as it is not clear to me that the suggested reason for this difference is definitively linked with a different airmass.

Page 3115, line 20: variation should be "variations"

Figure 6: "Climatological" in the x-axis caption is spelled incorrectly.

References: There are two Schneider, 2010 references. One of these should be labeled "b". There are numbers following each reference that I think are page numbers where references are quoted. These should be removed.

All OK. – Thanks!