Atmos. Meas. Tech. Discuss., 7, C4354–C4359, 2014
www.atmos-meas-tech-discuss.net/7/C4354/2014/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Upper-troposphere and lower-stratosphere water vapor retrievals from the 1400 and 1900 nm water vapor bands" *by* B. C. Kindel et al.

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Received and published: 31 December 2014

1. The Global Hawk (GH) flight lines including the vertical profiling need to be given a geospatial context. I had to pull the GH navigation data to see that the flight lines were over open ocean and within "the tropics." This is also important to the MODTRAN modeling parameters. Suggest either a map with continental boundaries or a lat/lon plot of the ATTREX flight track with the profiling stations indicated.

Response 1. A map of the flight lines and the position of the vertical profiles has been created and added as a second panel to Figure 3.

2. Figure 1 is not mentioned in the text. Consider connecting Figure 1 to a point you would like to emphasize or over plot the average NOAA Water instrument vertical profile to demonstrate how typical a measured winter tropospheric profile compares/contrasts with a full TOA modeled profile.

Response 2. Figure 1 is mentioned in the text; see lines 18-19 of section 2. The paragraph comprised of lines 15-20 discusses the vertical distribution of water vapor in the tropics and Figure 1 is an illustration of that.

3. Figure 3. On my 32" monitor, I have all your plots zoomed to 200%. However, I still have difficulty "seeing" specific information in your plots. If you want to make the point on the right transmittance plot, rescale the plot to a minimum of 0.98 to see the differences in the minima of the water vapor "doublets" between 14 and 18 km respectively to TOA.

Response 3. It is a bit unclear if the reviewer is referring to Figure 3, which is a plot of the vertical profile of the aircraft from the first science flight. In any case, the comment on expanding the vertical scale of the plots to give the reader a better picture is a good one, so figures including transmittances and the residual transmittances have been rescaled. These include figures 6, 7, 8, and 9. A horizontal line at zero has also been included in the residual plots.

4. Figures 6 and 7 are a bit of an eye chart. Recommend eliminating the "red traces" for the +/- one standard deviation as they cannot be seen. Recommend rescaling all the left side plots from 0.97 to 1.0 to truly show difference between modeled and measured transmittance as Figure 9 shows this clearly. (Internal "legends" could then be centered even with rescaling in the affected plots.) Recommend right side difference plots to be rescaled -0.01 to 0.01 and an overplot of a 0.00 horizontal "line." Overall, there is too much "white space" in plots when there is valuable information to display.

Response 4. We agree that the standard deviations (in red) are difficult to discern and this is precisely the point. They are included to illustrate that the horizontal variation in water vapor as the GH descends and ascends during the vertical profile have little effect on the retrieved water vapor amount.

5. Figure 11. The top left panel of the MODTRAN-modeled solar irradiances does not show any differences between 14-20 km – suggest doing a log plot. I'm not sure why the solar irradiances were modeled with a nadir view "straight overhead" – why not with the LOS indicated on Figures 6 and 7?

Response 5. We previously tried a log plot to accentuate the differences between the spectra but it had little impact. Instead we've opted to include "zoom" windows for the two water vapor bands and plotted them with the solar irradiances. The modeling was done for the sun directly overhead because this is the shortest possible absorption path. This combined with the highest aircraft of 20 km indicates that the water vapor amounts are still within SSFR sensitivity to absorptance.

6. I believe what is plotted in Figure 2 is the MODTRAN [modeled] water vapor transmittance for MODEL=0 (tropical). Or is it MODEL=6 1976 US standard atmosphere? The "input" water vapor profile is redundant if the former is true. What is important here is the tropical default column integrated amount is 4.11 g cm-2.

Response 6. The water vapor profile is the tropical type; we have reworded this description to avoid any confusion. The integrated amount is given in the text. Lines 99-103.

7. It may be helpful to speculate why the second profile was approximately three times greater than the first profile rather than point out the disparity in Figure 5. Is this variability to be expected seasonally or geospatially? Or is the profile an outlier and should be not considered in your population size? I quickly checked SST anomalies produced by JPL for that area.

Response 7. The much larger amount of water is interesting in this case but trying to explain its cause is beyond the scope of this work. This work focuses on the technique

and feasibility of using solar irradiance to retrieve small amounts of water vapor found in the upper atmosphere. It is something of an outlier but the agreement between the NOAA water vapor instrument and solar irradiance retrieval shows that it is not in error and should not be discarded.

8. It is important to point out that the MMS produces profiles of static pressure in addition to total pressure. The reason for this is that MODTRAN input that you used was equivalent to radiosonde data which uses static pressure.

Response 8. The MSS pressure description has been modified include the word static. Lines 206-207.

9. "The CO2 mixing ratios were set to 392 ppmv." Is that the MODTRAN default or did you use the in situ measurements from the Picarro Cavity Ringdown Spectrometer onboard the GH? You make a point in saying that the O2 and CO2 absorption features in the NIR "are of little interest to this work other than to note their presence in the spectra" (section 4, line 23). So, is the CO2 amount important?

Response 9. This paper is strictly about water vapor in the atmosphere. CO2 has no impact on the water vapor retrieval. This only serves to confuse the reader and so we have removed the sentence about CO2 mixing ratio that was from the Piccaro measurement.

10. "Computed spectra were convolved with the slit function. . ." If you truly did a FFT convolution then the statement is true. Otherwise, a "spectral convolution" was done on the MODTRAN output.

Response 10. The wording has been changed to "spectrally convolved". Line 237.

11. Perhaps a sentence which ties in the objective of the ATTREX campaign would strengthen the summary. Suggest: "Monitoring the oceanic water vapor as it enters the TTL at spatial and vertical scales ranging from the micro to macro levels from high altitude aircraft may help understand some of the complexities of climate change.

Water vapor profiles at these spatial scales cannot be retrieved from current satellites."

Response 11. The recommendation to include some words about ATTREX and the role of airborne measurements is a good one. Some text has been added to the Summary.

12. If there are cirrus clouds (verified by CPL data) in "dive 2," the profile should be excluded from the profiles used in the analyses. While cirrus clouds are the easiest clouds to model in MODTRAN, one still needs additional data (other than from CPL) to determine the cloud height. I believe the paper is better served with retrieving the water vapor profiles from clear skies to demonstrate the feasibility and robustness of the methodology.

Response 12. We agree with the reviewer here. This technique is best used in clear sky conditions and modeling the cloud is beyond the scope of this work. However, the agreement of the water vapor amounts between SSFR and the NOAA in situ instrument is quite good despite the presence of what must be an optically thin cloud. Most importantly, as the other reviewer pointed out, the presence of a cloud is revealed by the ice absorption in the 1450-1600 nm range of the SSFR transmittance spectrum. This illustrates one possible method to screen for cloud contamination without the aid of lidar or other instruments; to remove it would be a mistake. Some text has been inserted to describe the evidence for cloud contamination and the usefulness of this absorption feature in screening for cloud contamination. Lines 262-270.

13, The marine aerosols in the GH flight track sampling points are typically concentrated within the first two kilometers (ASL) which can be modeled easily with MODTRAN (with or without CPL data as input). What is important is the presence/absence of volcanic aerosols above the GH FL, (aircraft altitude). Again, one would have to verify that the GH FL track was not affected in the temporal or geospatial domain by high[er] altitude aerosols, something that can be easily done.13.

Response 13. Aerosols are concentrated in the lowest few kilometers of the marine environment. Significant aerosol, if present at these altitudes, would likely come from a

volcanic eruption. In the modeling preformed here the MODTRAN "background stratospheric" aerosols were used. A check of the aerosol extinction in the wavelengths of the water vapor bands at these altitudes from MODTRAN indicates that aerosols could not significantly influence the signal ($\sim$10-4 km-1 extinction). If a volcanic eruption had taken place during ATTREX this would be something to consider-it did not and therefore, was not considered. Lines 227-229.

14. In order for the results to be "reproducible," I agree with Referee #1 that more information on input parameters for the MODTRAN modeling should be described.

Response 14. More information about the MODTRAN inputs has been incorporated into the text. Lines 224-229.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 10221, 2014.