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Atmospheric Measurement Techniques Discussions

Interactive comment on "Single-footprint retrievals of temperature, water vapor and cloud properties from AIRS" *by* Fredrick W. Irion et al.

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General comments:

The authors describe a 1-D variational retrieval of temperature, atmospheric constituent gases, and cloud properties from AIRS observations (AIRS-OE) and co-located operational MODIS cloud property retrievals. Multiple retrieval strategies are employed based on the availability of MODIS cloud properties and their sub-pixel characteristics within an AIRS FOV. The paper fits well within the scope of AMT and provides a sufficient contribution to scientific progress in the field of remote sounding from hyperspectral IR measurements.

The layout of the paper is logical and the algorithm flow is well described; however, there are significant technical and material deficiencies that need addressed before acceptance to AMT.

For instance, some important details of algorithm settings (e.g., measurement noise) are missing from the text and the authors' description of the retrieval information content/error estimation is sometimes confusing. In addition, the sections on the discussion of results, validation of the AIRS-OE algorithm against matched radiosonde, and comparisons to operational AIRS v6 (and conclusions drawn from the results) are lacking enough detail to fully assess the comparative pros, cons, and skill of the AIRS-OE retrieval relative to existing products.

Specific comments:

"QA" is not defined (pages 13, 14, 15) in the text.

Page 1, Line 20: "higher vertical resolution of retrieved temperature and water vapor" There are other advantages of thermal infrared data – e.g., trace gas sensitivities, sensitivity to aerosol, . . .

Page 2, Line 10: . . . the Stand-alone AIRS Radiative Transfer Algorithm, Delta-Four Stream (SARTA-D4S; Ou et al., 2013). There is another extension to the SARTA package that enables the simulation of outgoing radiance in the presence of cloud and aerosol and that is directly applicable to AIRS studies: DeSouza-Machado, S., Strow, L. L., Imbiriba, B., McCann, K., Hoff, R., Hannon, S., Martins, J., Tanré, D., Deuzé, J., Ducos, F., and Torres, O.: Infrared retrievals of dust using AIRS: comparisons of optical depths and heights derived for a North African dust storm to other collocated EOS A-Train and surface observations, J. Geophys. Res., 115, D15201, doi:10.1029/2009JD012842, 2010.

Page 4, Line 2: How is the radiance noise covariance prescribed? AIRS detector modules have significant correlated noise among channels within each module (e.g., http://onlinelibrary.wiley.com/doi/10.1256/qj.03.93/pdf., page 1480 and Tobin, et al., "Hyperspectral data noise characterization using principal component analysis," J. Appl. Remote Sensing, v1, 2006). Does the algorithm account for the correlation in the observation covariance, or does it only use a diagonal matrix? How is the noise estimated or prescribed? Are forward model error components estimated or used in addition to instrument noise? If so, how? Do you use a bias correction between observations minus calculations; if so, how is it estimated?

Page 5, line 35: "use extrapolated cloud absorption and scattering parameters, and may not be reliable." This statement is not clear. I assume that the cloud absorption and scattering parameters are restricted in the Forward Model lookup tables between 5-85 microns, but it is not clear from the text.

Page 8, line 2: "...of uncertainties in the scattering/absorption ratio (Nakajima and King, 1990; Nakajima et al., 1991)" ... perhaps also due to the 4 stream approximation of the forward model employed in this study.

Page 8, Line 13: "...First, leaving other variables fixed, only τcld is retrieved...The resultant spectral fit from this initial retrieval can be poor." If the spectral fits are poor after this first attempt how is convergence/iteration stopping criteria determined? This particular detail of the algorithm flow seems important and critical to the success or failure of the algorithm to converge to the optimal solution in subsequent steps.

Page 8, Line 23: "...nearly linear in vicinity of the solution" and a priori? Per the above comment about poor spectral fits after the first attempt, I wonder how well this linear assumption holds for all retrieval strategies employed. The authors should address the potential failure of this assumption and/or reasons why the assumption is valid in greater depth.

Page 9, Line 33: "...on the spectrum" suggest to revise to "measurement spectrum."

Pages 9-10: How does the vertical resolution of the AIRS-OE algorithm compare to the operational AIRS V6 vertical resolution.

Page 10, Line 12-13: Continuing the previous comment. "... depend on the amounts of trace gases present, the temperature lapse rate, the particulars of the cloud field" These statements are true for any retrieval strategy (cloud-clearing, cloudy, or clear)

from AIRS or any other instrument. The authors continue "...since the AIRS-OE retrievals are simultaneous and not sequential...," which seems to be a nod to the operational AIRS algorithm. Consider adding a reference (e.g., Maddy, E.S. and C.D. Barnet 2008. Vertical resolution estimates in Version 5 of AIRS operational retrievals. IEEE TGRS. v.46 Section 2A, p. 2377) to back up the first statement and provide contrast the second statement.

Page 10, Line 25: How is the noise error covariance defined? See above.

Page 10, Lines 29-30): "...spectral biases or other errors that are correlated across observations" calibration uncertainty, correlated instrument noise (if not included in measurement covariance ... see previous comments).

Page 12, Line 23-25: "...The morphology of the AIRS-OE retrieval fields are similar to the a priori, and the morphology of the averaging kernel fields are similar to each other. " This statement is confusing. Please revise for clarity..

Page 13, Line 26: "...for each of these..." Consider revising to "for each retrieval quantity"

Page 13, Line 30: "...unphysically high values..." It's unclear whether the authors are referring to unphysically high differences (>100%) or unphysically super-saturated retrievals.

Section 4.3: Spatial resolution is one of the main differences between AIRS-OE and AIRS V6. Have the authors performed a comparison between quality controlled AIRS-OE averaged onto the AIRS V6 effective footprint (i.e., 3x3 spatial average)? A short discussion of this type of comparison is suggested.

Page 13, Line 33: "IGR" should be IQR.

Page 14, Lines 11-16: Authors provide a qualitative description of the "a priori" sensitivity of the algorithm. A more detailed quantitative would be informative to the reader.

Page 14, Line 30: "…lower down…" consider removing.

Page 14, Line 33: "…because the water vapor retrieval was too high…" Too high relative to what? Consider revising for clarity. For instance, "because the reported retrieval water vapor was supersaturated."

Figures 13, 14 and corresponding text: The AIRS-OE a priori statistics (bias and IQR) are generally more well behaved as compared to both the AIRS v6 and AIRS-OE retrievals and in some cases perform better than both physical retrieval algorithms (esp. near surface for temperature). I wonder how much do the cloud/other variable retrievals compensate for other variable/cloud errors. A more detailed analysis and/or discussion of an assessment of AIRS-OE retrieval increments of profile variables as well as surface temperature, and cloud optical properties relative to a priori as compared to Radiosonde and correlative CloudSat/Calipso retrievals should elucidate cross-talk between retrieval parameters is suggested.

Page 15, line 30: "are low" – how low?

Page 16, line 9: "…has an information content analysis … operates both within and across different atmospheric parameters." It is unclear what is meant by "operates both within and across." Do you mean that the information content analysis provides diagnostic information regarding the temperature retrieval, water retrieval, etc. and interactions between temperature and water, temperature and cloud, water and cloud, etc. If so, please revise.

Page 16, line 16-17: " … incorporating scattering by dust …" Is the radiative effect of an atmospheric dust signal in AIRS measurements large enough to cause significant degradation in a 1DVAR retrieval? Consider adding a sentence and or reference detailing why this is might be important (e.g., Maddy, E., DeSouza-Machado, S., Nalli, N., Barnet, C., Strow, L., Wolf, W., Xie, H., Gambacorta, A., King, T., Joseph, E., Morris, V., Hannon, S., and Chou, P.: On the effect of dust aerosols on AIRS and IASI operational level 2 products, GRL, 39, L10809, doi:10.1029/2012GL052070, 2012. 446)

Page 16, line 17-18: Again, does the 4-stream RT algorithm limit the use of AIRS shortwave channels? Are there any other specific limitations with forward modeling that need to be addressed before the 4micron band could be utilized? Scattering tables, spectroscopy, etc.?

Page 16, line 32: "…compare well with operational AIRS-V6…" how well? how is it distinguished from AIRS v6? There are a number of characteristics (potential advantages and distinguishing features) of the AIRS-OE algorithm as compared to the AIRS v6 algorithm (higher spatial and vertical resolution, potentially better cloud characterization, comparable statistical results, etc.); however, these are scattered within the text and conclusions. It would be helpful to re-organize the conclusions such that these characteristics are emphasized.

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