

Single Footprint Retrievals for AIRS using a Fast TwoSlab Cloud-Representation Model and All-Sky Radiative Transfer Algorithm”

by DeSouza-Machado et. al.

We thank the reviewers for their comments, questions and suggestions to improve the paper. Below we detail our responses to their concerns. For ease of review, we type-faced the reviewers questions in blue. When we refer to pages and line numbers in our answers, the context should make it clear whether we are talking about the original manuscript or our current revised manuscript.

Reviewer 1

Specific comments

1) Page 2, lines 4-8: In addition to (or instead of) citing [Weisz et al. 2007] I suggest the following more recent paper

Thank you for making us aware of this paper, we have replaced the 2007 reference with the 2013 reference. Page 2, lines 4-8 now read as follows

”Earlier single footprint retrievals using eigenvalue regression methods have been used with these all-sky (cloud and clear) radiances (see for example Weisz et al. (2013)) ...”

2) Furthermore, Kahn et al. (2014), who also performs cloud parameter retrievals on individual scenes, should also be mentioned here first rather than on page 30.

We have modified the manuscript by moving lines from (old manuscript) Page 30, lines 28-30 to page 3, Lines 2-5 (new manuscript)

”We note here the regression based single footprint retrievals provide cloud top information; similarly cloud phase and cirrus effective diameter and optical thickness retrievals are generated at AIRS single footprint resolution (Kahn:2014) after the L2 thermodynamic retrievals are done, in a separate step that keeps all other retrieval variables constant.”

3) Regarding climate studies, a publication worth mentioning is Smith et. al (2015), which describes change in the climate system using single field-of-view hyperspectral retrievals under all sky conditions.

We have added the following sentence towards the end of the Conclusions section (Page 33, Lines 25-27)

”Smith:15 discusses climate change studies using the homogeneous geographic sampling resulting from single footprint retrievals that are physical-statistical based (whereas ours are physical based, using an allsky RTA through all the iterations).”

4) Section 2.1: Please state which AIRS channel property file you are using to extract the good channels as well the corresponding NEDT values (shown in Fig. 2)

AIRS channels that have remained stable over the life of the mission were selected for these retrievals to allow accurate trend studies in future work. These channels were further filtered by us after looking at the time series of over-ocean biases between AIRXBCAL (which contains scenes deemed to be clear for each day) scenes and simulated radiances from the ECMWF ERA-Interim reanalysis.

We have re-arranged Section 2.1 and added the following paragraph

”About 1500 AIRS channels that have remained stable over the life of the AIRS mission were selected for this paper. retrievals. This was done by examining the statistics of the 14+ time series of AIRS radiances (of all channels) in the AIRXBCAL clear-sky data set (ocean scenes only), which contains scenes deemed to be clear for each day. More details about this channel list can be obtained from the authors. NeDT values used in this paper come from the v9.5.0 (2011/07/01) file available at <https://disc.gsfc.nasa.gov/information/documents?title=AIRS>

5) Can you state what version of PCRTM is used here?

We used v2.1, that information has been added to Page 6, Line 27. A later version has Non-local thermodynamic equilibrium added on for the 4 um channels, and improved solar scattering computations. However we avoided using those short wave channels throughout the paper, and so this should not affect the results presented here.

6) Section 4.2: the motivation for using the 1231 cm⁻¹ channel in the figures and results that follow should be clearly stated here first. It would be also useful to state the corresponding wavelength and the MODIS band equivalent.

Old manuscript, Section 5, Page 13, Lines 1-3 have now been moved towards the end of Section 4.2 (Page 12, Lines 3-6). We have added in the wavelength information, but have chosen not to provide the MODIS band equivalent since that instrument's Channel 5 spans 1230-1250 cm⁻¹ and contains many weak water lines. Conversely AIRS Channel 1291 (centered at 1231 cm⁻¹) spans about 1 cm⁻¹ and so is mainly affected only by the water continuum.

Technical Comments

1) Page 3, line 3: remove could

Fixed

2) Page 3, lines 13-15: this sentence is unclear, please rewrite

Fixed, these lines have been changed to Page 3, Lines 15-20

"The OEM methodology provides the user with objective diagnostic information, such as error estimates of the retrieved profiles, Averaging Kernels (AKs) and the information content of the measurements *via* number of Degrees of Freedom (DOF). For example we show later in this paper that our single footprint retrievals have much lower DOFs under thick clouds than in almost clear scenes, which means our retrieval mostly returns the *a-priori* below thick clouds, and can only adjust the profile above such clouds."

3) Page 6, line 13: use added instead of adding

We have rewritten this sentence as "PCRTM calculates reflectance and transmittance of water and ice clouds using a parametrization scheme (Liu et al., 2009) based on a look-up-table trained using 32-stream Discrete Ordinates Radiative Transfer Program for a Multi-Layered Plane-Parallel Medium (DISORT) (Stamnes et al., 1988) and using single scattering properties calculated by Yang et al. (2002), Wei et al. (2004), Huang et al. (2004), and Niu et al. (2007)"

4) Page 6, line 26: add space after does

Fixed

5) Page 7, line 3: add space after the comma in (CLWC, CIWC)

Fixed

6) Page 11, line 18: use lower-case L in TwoSLab

Fixed

7) Page 11, lines 19-21: should be become (not becomes), show (not shows), and are much smaller instead of is much smaller.

Fixed

8) Page 11, line 26: use were proportional (not was proportional)

Fixed

9) Pages 11, 14, 15 etc.: SARTA TwoSlab or SARTA/TwoSlab? Please use consistent terminology.

Fixed, now consistently SARTA/TwoSlab

10) Page 13, line 13: remove the comma after differences

Fixed

11) Page 13, line 15: inconsistent use of parentheses for in-text citations (throughout the paper)

Fixed

12) Page 14, line 10: (PDFs) instead of (PDF)s.

Fixed

13) Page 14, line 13: please rewrite as is evident in from Figures 4 and 5

Fixed

14) Page 16, line 1: use shows instead of plots

Fixed

15) Page 16, line 3: there is a space missing after the comma in (1),(2)

Fixed

16) Page 16, line 6-7: suggest using decreases instead of lowers

Fixed

17) Page 16, line 21: led instead of lead

Fixed

18) Page 17, line 2: use either pdfs or PDFs

Changed to PDFs

19) Page 17, line 17,18: please rewrite They could either at too low an . . .

Changed to "They could either be at too low an altitude, or they could be at the right altitude and either have low optical thickness or a low cloud fraction."

20) Page 20, line 23: use is a block diagonal matrix instead of is block diagonal

Fixed

21) Page 21, line 3: physically-based (not physically-gased)

Fixed

22) Page 21, line 29: add full name for MERRA

Fixed, and added reference to Page 23, Line 8 : "Modern Era Retrospective-analysis for Research and Applications (MERRA) (Gelaro et al., 2017)"

23) Page 24, line 9: delete repeated after the retrieval

Fixed

24) Page 24, lines 15-16: remove parentheses

Fixed

25) Page 27, line 4: remove] after 14

Fixed