

Review of Global Spectroscopic Survey of Cloud Thermodynamic Phase at High Spatial Resolution, 2005-2015, by Thomson et al.

**Recommendation:** this paper has the potential to be an interesting contribution to knowledge, but requires major revision before being accepted as a publication.

### Major comments

- The comparison with AIRS is flawed. It appears to be a purely statistical comparison, involving mainly land scenes on the part of Hyperion, and global scenes on the part of AIRS. Given the variability of clouds and the sharp differences between maritime and continental clouds, the AIRS data should have been subsetting to match the Hyperion locations. Mention should be made of the differences (or similarity) between the Hyperion and AIRS sampling: I think that they sample at completely different times of the day? So even if both instruments were retrieving cloud phase perfectly, the comparison would be flawed by the different sampling strategies. The results shown in Figs. 6, 7, A1 and A2 consequently are troublesome to interpret. They should have addressed the sampling errors of each instrument, not simply a vague error bar for Hyperion and nothing for AIRS. The comparison is also weakened by the empirical correction factors to AIRS data discussed in section 2.5.
- The definition of LTF is flawed. The signal measured is based on the absorption of solar radiation integrated over the entire photon pathlength, yet eq. 2 refers only to the thickness of the cloud. By their nature, clouds are heterogeneous, so that horizontal variability dominates the radiative transfer process. [This also means that the retrieval technique is at a coarser scale than the postulated 30 m due to the effects of radiative smoothing, and is likely closer to 100 m.] I think this is correctly acknowledged in p.4 line 13 ff. However, it is not really clear whether the LTF is being interpreted correctly. I take it to be the fraction of average photon path that is liquid. Not the fraction of the cloud that is liquid, which would require all paths to extend to the cloud base. An opaque cloud has little transmission, so that most of the reflected paths relate to the top of the cloud. This probably doesn't matter much for the Hyperion retrievals standing alone, but becomes troublesome when compared to other techniques that sample cloud tops differently. It would be good to see a clearer discussion of what is meant by the 'effective proxy for thermodynamic phase'.
- Section 2.3 is a strange, stand-alone paragraph that seems incomplete. How is 'dominant' defined? Greater than 50%? What comparisons were made with historical datasets? This section should be rewritten to provide better context, or incorporated elsewhere.
- Section 2.4 presumably refers to the uncertainty in determining the LTF of a single scene, but this is not clear. It also stops abruptly with no relation to the

results. This needs to be rewritten for clarity and context.

- Section 2.5 should provide a reference to how AIRS obtains cloud phase and whether this has ever been validated.
- The use of the word 'trends' p.5, p7, p.13. This is better reserved for long term climate change. Here we are looking at 'relative dependence on latitude' or similar.
- Fig. 4 shows results for clear retrievals, yet the scene looks completely overcast. Are these all in error, despite the low values of  $\chi^2$  for many of these? Given the range of  $\chi^2$  shown, presumably the only results retained were when  $\chi^2$  was less than some threshold? This could be discussed better.
- Fig.5 is too cryptic for the typical reader. If the vapor transmittance around 1.4  $\mu\text{m}$  is zero, how can there be any reflectance to work with? Does the theory include the vapor paths both above and within the cloud? Probably need to explain what is meant by transmittance in this context.
- Normalization of occurrence: p.6, l.11 is  $-60$  to  $+60^\circ$ , Fig. 6 is  $0$  to  $60^\circ$ . Which is it? Is the normalization done separately for each cloud phase? Are the AIRS data similarly normalized?
- Fig. 8 is flawed by the nonuniform sampling with latitude. Perhaps an indication of the relative number of samples per histogram would help.
- p.10 line 9. Appendix 4? Appendix A.
- Fig. 9 shows NH and SH curves for extra tropical clouds, but which is which? Eq. 14-16 don't seem to match the values on the figure.
- p.13, line4. This caveat comes far too late in my opinion as it dominates the comparison throughout. Note that CALIOP also offers high-resolution phase information that also has fewer sampling limitations.