Comments on “Cloud information content analysis of multi-angular measurements in the oxygen A-band: application to 3MI and MSPI” by Merlin et al.

This manuscript presents a theoretical study of the information content for retrieving cloud top height (CTOP) and cloud geometrical thickness (CGT) from multi-angular O2-A band satellite observations. It is first demonstrated that the “O2-A band ratio”, which is usually used in traditional O2-A band CTOP retrieval algorithms, is actually dependent not only on CTOP, but to large extent also on CGS. It is then suggested that this sensitivity could be utilized to retrieve both CTOP and CGT from the two future multi-angular O2-A band instruments—3MI and MSPI. A simple look-up method is described, followed by an information content analysis using the framework by Rodgers (2000). It is concluded that there is enough information to retrieve both CTOP and CGT for optically thick clouds from multi-angular O2-A band instruments like 3MI and MSPI.

This is an innovative study of a new remote sensing concept for cloud property retrievals using the future multi-angular O2-A band satellite instruments. The topic is suitable for AMT. However, I have a few major concerns about the presented retrieval method and a number of minor questions/comments. I’d like to see them clarified before I can recommend the paper for publication.

Major comments:

1) **My first major concern is how cloud inhomogeneity and 3-D effects would influence the presented retrieval method.** The retrieval method presented in Figure 6 utilizes the difference between the observations from viewing angles. An implicit underlying assumption is that the difference is due to the variations of CTOP and CGS. However, this is a valid assumption only for plane-parallel clouds. In reality, many other other factors, in particular cloud inhomogeneity and 3-D effects, could also cause the cloud reflectance differences between different viewing angles. In fact, there are already a couple of studies on this issue. For example, [*Liang and Di Girolamo*, 2013] argued that the cloud reflectances from different MISR viewing angles would be consistent if clouds were plane-parallel. However, after analyzing global MISR observations, they found that in most regions of the globe, there are significant inconsistency of directional cloud reflectance between different MISR viewing angles. This indicates that most clouds can not be considered as plane-parallel, especially when clouds are broken and when the sun is low. There are also a number of other studies on this issue [e.g., *Loeb and Coakley*, 1998; *Várnai and Marshak*, 2007; *Di Girolamo et al.*, 2010]. Based on these studies, I think cloud inhomogeneity and 3-D effects could have strong impacts on the retrieval algorithm described in this study. Unfortunately, I found no discussion on this important issue.

   The bowtie effect is another important issue to consider. Note that the pixel size could change significantly from nadir to oblique viewing direction.

Here are my suggestions. First, it needs to be pointed out clearly in the paper that the current method is based on plane-parallel cloud assumption. Second, the above studies should be mentioned in the text to remind the readers that multi-angular cloud observations could be strongly influenced by cloud inhomogeneity and 3-D effects, and therefore current algorithm is only applicable to homogeneous clouds. Finally, it should be clarified how to determine cloud homogeneity using the standalone 3MI or MSPI observations and what is the appropriate cloud homogeneity such that the current method can be applied. It would be even better if some sensitivity study can be performed using 3-D radiative transfer model.

2) It is mentioned a few times in the paper that "Previous studies have not formally considered the impact of measurements and forward model errors on the retrievals." Well, this is not true. For example, more than 15 years ago, [*Heidinger and Stephens*, 2000] already did a comprehensive analysis of the information content of the O2-A band for cloud observation, in which not only measurements and forward model errors, but many other factors are considered. In fact, I think most of the information content studies would consider the measurements and forward model errors. I'd suggest not to over-emphasize on this rather trivial point.

3) I'm also disappointed by the lack of explanation of the physics underlying the retrieval algorithm. For example, it is understood that the mean O-2 band ratio is chosen as one dimension of the look-up-table in Figure 6. But what is the reason of using standard deviation? Why not to use the difference between two directions, such as nadir and oblique viewing direction to obtain largest contrast? Why is standard deviation sensitive to CTOP and/or CGS? Some discussions are needed there.

Minor comments

4) The current title is too large and can be revised to be more specific, something like "Investigate the possibility of simultaneous retrieval of CTOP and CGS from multi-angular O2-A band observations"
5) The Abstract is different from Introduction. It should focus on key results not the motivations.
6) "In particular, the cloud cover vertical distribution has a significant impact on a large number of meteorological and climatic processes." What are meteorological and climatic processes? And references.
7) In simulation assumptions part, it should be mentioned whether and how in-cloud O2 absorption is treated in the simulation, and whether it is important.
8) What is the definition of O2-band ratio? Equation should be given.
9) Are aerosols, either below or above clouds, considered at all in this study? Why are they not important?
10) Why are the *a priori* values for CTOP and CGS chosen at 5km? 5km seems rather small for CTOP, no? References should be given here. It should be mentioned whether and how the results are sensitive to the choice of *a priori* values.

References

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